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NOTES ON THE PHLEBOTOMUS OF PANAMA, XIV (DIPTERA, PSYCHODIDAE) P. VESPERTILIONIS AND RELATED SPECIES[1]

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ABSTRACT

A key is given to the males of the seven known Central American species of this group, and a partial key to the females; among the seven there are three pairs of species whose females are not distinguished from one another. New species are: *P.* **viriosus,** Panama and Costa Rica; *P.* **steatopygus,** Chiapas; and *P.* **isovespertilionis** (= *P. vespertilionis*, part, F. & H. 1947), Panama. Notes on distribution and habitats are given for *P. deleoni* F. & H., *P. vesciferus* F. & H., *P. beltrani* Vargas & Diaz Najera, and *P. vespertilionis* F. & H.

The species treated here appear to be a mainly Middle American group, only one species having so far been reported from south of Panama. Several of the species seem to be associated with bat roosts, in caves, ruins, or hollow trees, though several attempts to feed one of the species on bats in the laboratory have been unsuccessful.

Structurally the group is characterized chiefly by the inflated lateral lobes of the male genitalia, a condition which, though striking, may eventually prove of less phylogenetic importance than the structure of the spermathecae. The lateral lobes bear numerous and evenly distributed setae on both the inner and outer aspects, most of which are lost during the manipulations of preparing the specimen for mounting. Their sockets have been omitted from the accompanying drawings, as their distribution appears similar in all the species. In addition, the males of all species have a basal tuft of setae on the inner aspect of the coxite, simple parameres, relatively short and thick genital filaments with expanded or modified tips, and a style with one spine situated quite close to the base of the segment. The females all possess broad unarmed pharynges, cibaria with four large median teeth and usually clusters of small lateral inwardly directed spines and a well developed chitinous arch. The abdominal setae are largely erect; there are no setae on the eighth segment, while the ninth tergite bears long ligulate setae. The cerci are rather short and triangular. The spermathecae are of two quite distinct types. Those of *vesiciferus* F. and H. and *deleoni* F. and H., figured by us in 1947, have a very large bladder-like lateral expansion and a slender terminal knob which appears to protrude through an aperture in the side of the spermatheca. Both the individual and common ducts are slender. The remaining species have ovoid wrinkled spermathecae, with what appear to be internal spine-like processes arising from thickenings in the cuticle, short terminal knobs, and short, usually thick, individual ducts arising from a broad common duct. The males of *vesiciferus* and *deleoni* differ from the remaining species in having the basal spine of the style well developed, and the paramere with a small triangular protuberance below. Both sexes of all the species have the same palpal formula, 1–4–2–3–5, with a long fifth segment, long third antennal segment, simple slender ascoids, simple first three sternites, without median fenestrae, and very similar wing venation.

We present below keys to both sexes. That to females is based entirely on the spermathecae and depends on the appearance of these structures in phenol before mounting, so that it is of limited utility in separating specimens having the spermathecae shrunken. We are unable to find other key characters of utility, and in fact cannot separate the females of *vesiciferus* from *deleoni*, *vespertilionis* from *isovespertilionis*, or *beltrani* from *steatopygus*. They have been associated

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with their respective males on the the basis of geographic distribution or, in the case of *vespertilionis* and *isovespertilionis*, by rearing.

KEY TO MALES

1. Style with basal spine long, nearly as stout as the other spines. Parameres with a small triangular tooth below 2
   Style always with 3 spines, the basal spine reduced to a slender bristle. Parameres without a triangular tooth below 3
2. Style with 4 spines and a subterminal seta. Lateral lobes longer than coxites ..... **deleoni**
   Style with 3 spines and a subterminal seta. Lateral lobes about equalling coxites ..... **vesiciferus**
3. Style with 2 apical spines but no subterminal seta, rarely with a rudimentary bristle-like median spine. Lateral lobes very broad, less than 4 times as long as greatest width. Genital filaments over 3 times length of pump ..... **viriosus**
   Style with 1 apical and 1 median spine and a subterminal seta. Lateral lobes over 4 times as long as broad. Genital filaments about twice length of pump 4
4. Style markedly shorter than coxite, the median spine about its middle, both main spines strongly spatulate. Lateral lobes broad, about 5 times as long as greatest breadth and nearly as long as coxite and style together ..... **steatopygus**
   Median spine of style inserted well distal to middle of segment. Lateral lobes 6 or more times longer than broad 5
5. Style nearly as long as coxite, the median spine inserted at two-thirds the distance from base to apex of segment. Setae of basal tuft inserted in straight rows ..... **beltrani**
   Style about two-thirds length of coxite, the median spine more apical, inserted at about four-fifths the distance from base to apex of segment 6
6. Parameres slender, about five-sixths length of coxite, their dorsal setae confined to the apical third of structure ..... **isovespertilionis**
   Parameres stouter, about three-fourths length of coxite, their dorsal setae more numerous, covering apical half of structure ..... **vespertilionis**

KEY TO FEMALES

1. Spermathecae with large bladder-like lateral expansion ..... **vesiciferus, deleoni**
   Spermathecae ovoid, wrinkled or irregularly and weakly annulated 2
2. Individual ducts slender, longer than spermathecae, equalling the slender common ducts ..... **viriosus**
   Individual ducts very short, wide, less than length of spermathecae 3
3. Common duct narrower, at least three times as long as broad ..... **vespertilionis, isovespertilionis**
   Common duct broader, not more than twice as long as wide ..... **beltrani, steatopygus**

Phlebotomus deleoni Fairchild and Hertig

1947, Ann. Ent. Soc. America 40 (4): 622, Pl. 3, figs. 1–3 (♂, ♀; Peten, Guatemala). Barretto, 1950, Arq. Hig. Saude Pub., S. Paulo 15 (46): 215. Vargas and Diaz Najera, 1953, Rev. Inst. Salub. Enf. Trop., Mexico 13 (4): 311 (Palenque, Chiapas, Mexico). Barretto, 1955, Rev. Brasil. Ent. 3: 183 (as *Sergentomyia*). Fairchild, 1955, Ann. Ent. Soc. America 48 (3): 194.

In addition to the types, we have now seen 16♂, 7♀ from Palenque and Santa Maria, near Cintalapa, Chiapas, Mexico, and from Lancetilla, Tela, Honduras, taken at light, in bat caves, and in tree buttresses.

Phlebotomus vesiciferus Fairchild and Hertig

Figure 20

1947, Ann. Ent. Soc. America 40 (4): 620–622, Pl. 2 (♂, ♀; Panama). Barretto, 1950, Arq. Hig. Saude Pub. S. Paulo 15 (46): 225. Rosabal, 1954, Invest. Epidem. No. 3, Min. Salub. Pub., San José, Costa Rica p. 28, Pl. 8 (Costa Rica). Barretto, 1955, Rev. Brasil. Ent. 3: 186 (as *Sergentomyia*). Fairchild, 1955, Ann. Ent. Soc. America 48 (3): 194.

This species has proved not uncommon in Panama, especially on the Atlantic side of the Isthmus. We have taken it from 26 localities in Panama, 3 in Costa Rica and 1 in Nicaragua, from daytime resting places and in light traps. It does not bite man. We include a figure of the head for comparison with a representative of the subgroup having more simple spermathecae.

Phlebotomus viriosus, new species

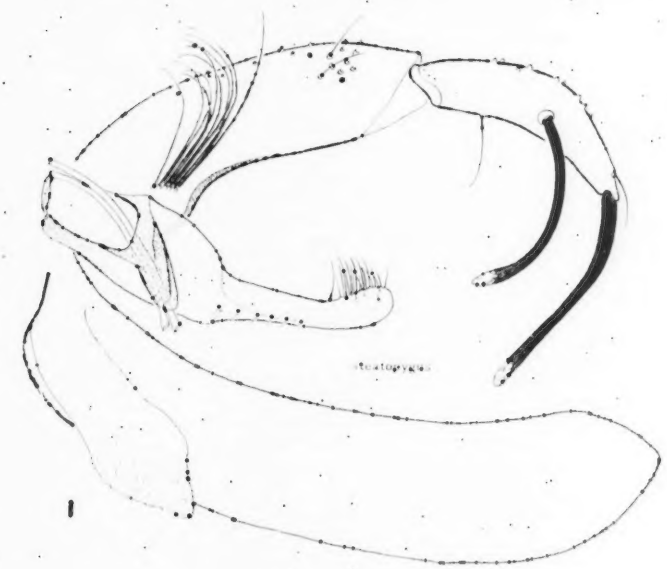
Figures 7, 9–12, 16–18

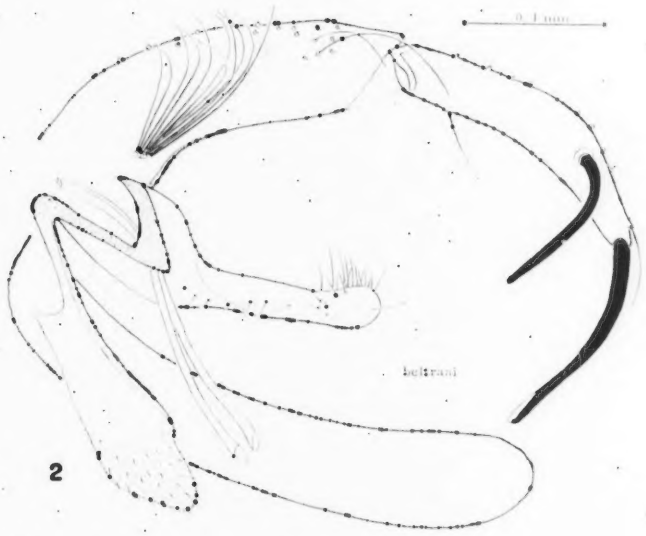
Male.—Length of wing 1.59 to 1.83 mm. Mesonotum, coxae, genitalia, and dorsum of abdomen moderately infuscated. Abdominal setae erect. Upper anepisternal setae 12 to 18, lower mesanepisternals 1 to 3, all slender. Eye a little less than three-fourths of head height. Proboscis less than head height. Pharynx slender, ridged at apex. Cibarium unarmed. Third antennal segment reaching well beyond end of proboscis, nearly to end of fourth palpal segment on intact head. Ascoids simple, slender, short, reaching about half the length of their respective segments, paired on all but the shortened terminal segment. Palpal formula 1–4–2–3–5, fifth segment less than second and third together, fourth greater than one-half third. Newstead's scales slender, on middle three-fourths of third segment. Genitalia as figured, differing from all others of this group in having two terminal spines on style and lacking a subterminal seta.

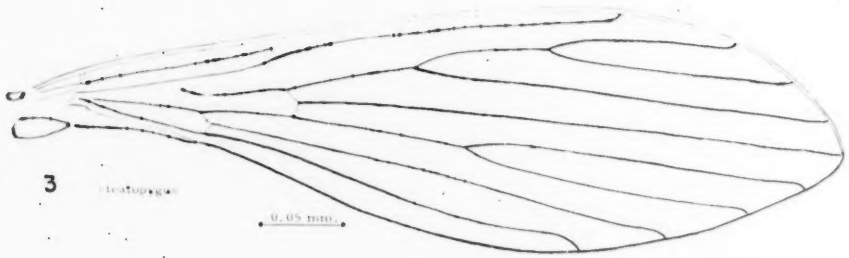
Female.—Length of wing 1.85 to 2.09 mm. Coloration as in male though slightly darker. Sides of eighth abdominal segment without setae. Ninth tergite with ligulate setae. Upper anepisternal setae 14 to 24, lower mesanepisternals 2 to 3. Eye as in male. Proboscis longer than in male but less than head height. Pharynx broad and well sclerotized, with fine ridges at apex. Cibarium with four horizontal teeth and strong chitinous arch. Third antennal segment reaching or slightly exceeding tip of proboscis, not

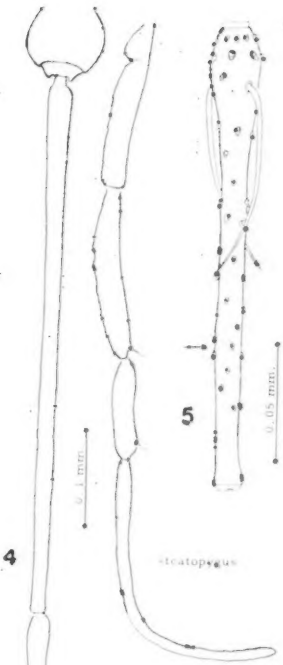
EXPLANATION OF PLATE I

FIG. 1.—*P. steatopygus*, male genitalia, paratype, slide 3110. FIG. 2.—*P. beltrani*, male genitalia, slide 3042, Sta. Maria, Chiapas. FIG. 3.—*P. steatopygus*, male wing, paratype, slide 2976. FIG. 4.—*P. steatopygus* male basal antennal segments and palpi, paratype, slide 3110. FIG. 5.—*P. steatopygus*, male antennal segment VII showing ascoids; the arrow indicates length of female ascoids; slide 2977, paratype. FIG. 6.—*P. steatopygus*, pump and genital filaments, paratype, slide 3110. Magnification is indicated by a scale line, the magnification for each structure being the same for all species.


steatopygus
1


0.1 mm.
beltrani
2


3
steatopygus
0.05 mm.


0.1 mm.
4
steatopygus

5
0.05 mm.

0.1 mm.
6
steatopygus

reaching end of third palpal segment. Ascoids longer than in male, reaching about five-sixths length of segment. Palpi as in male, but Newsteads' scales sparser. Spermathecae as figured, with relatively slender ducts.

Holotype male, slide 3927, Almirante, Bocas del Toro Prov., Panama, 24 March 1952, in rock crevices along stream near Yellow Fever Camp, A. Quiñonez coll. Allotype female, slide 4158, same locality and habitat as holotype, 18 Aug. 1952, W. Hils coll. Paratypes, 43♂, 13♀, mounted on slides, as follows: 42♂; 11♀, from same locality and habitat as holotype, May, Sept., Oct., Nov., 1951; Jan., Mar., May., June, July, Aug., Sept., Oct., Nov., 1952; Jan., 1953, Quiñonez, Hils, Trapido and Galindo colls.; 1♀, same locality, taken in tree buttress near camp 6 Jan. 1953, Hils coll.; 1♂, Pacuare, Costa Rica, 7 Feb. 1952, in rock crevices, M. Hertig coll.; 1♀, La Roca, Costa Rica, 29 April 1951 in tree buttress, R. Rosabal coll. In addition, we have examined and stored unmounted 161♂ from same locality and habitat as holotype with dates ranging from 15 Dec. 1951 to 7 April 1953; 1♂, same locality 17 Sept. 1952, taken in tree tops at night; 1♂, same locality, 20 Oct. 1952, taken in tree buttress near camp; 1♂, Lucas' Place, Water Valley, Almirante, 30 Jan. 1956, in tree buttress, Fairchild and Hertig colls.

The great preponderance of males and the fact that a single habitat in one locality furnished all but a very few specimens is noteworthy. This species differs most markedly from the remainder of the group in having two terminal spines on the style, and in lacking a median spine and subterminal seta. The presence in the figured specimen, though not in others, of a small seta at the point where a median spine would be expected, suggests the possibility that this spine has been rather recently lost and that the second terminal spine has replaced the subterminal seta of the other species.

Phlebotomus steatopygus, new species

Figures 1, 3–6, 15, 19, 21

Male.—Wing length 2.25 to 2.59 mm. Mesonotum slightly infuscated. Abdominal setae mostly erect. Upper anepisternal setae 10 to 14, lower mesanepisternals 3, all slender. Eye about two-thirds head height. Proboscis less than head height. Pharynx slender, cibarium unarmed. Third antennal segment much exceeding proboscis, reaching well beyond end of fourth palpal segment on intact head. Ascoids slender, simple, shorter than their respective segments, paired on all but the shortened terminal segment. Palpal formula 1–4–2–3–5, fifth segment slightly longer than second and third together, fourth about two-thirds of third. Newstead's scales long, slender, spatulate, on third segment only. Genitalia as figured, the specimens of this and *beltrani* selected for figuring have the basal tuft displaced upward so that the numbers of setae are clearly seen. Normally the setae lie in a plane perpendicular to the observer and appear almost fused into a pencil.

Female.—Wing length 2.28 to 2.57 mm. Coloration as in male. Abdominal setae as in male, none on sides of eighth segment, those on dorsum of ninth tergite ligulate. Upper anepisternal setae 10 to 14, lower mesanepisternals 2 to 4, all slender. Eye as in male. Proboscis slightly longer than head height. Pharynx broad and well sclerotized, with fine ridges at apex. Cibarium with four slender horizontal teeth and strong chitinous arch. Third antennal segment exceeding proboscis, reaching to end of third palpal segment on intact head. Ascoids as in male though slightly longer, paired on all but the shortened terminal segment. Palpal formula 1–4–2–3–5, fifth segment about equalling second and third together, fourth over half third. Newstead's scales as in male but more numerous and on apex of second segment as well as most of third. Spermathecae apparently as in *beltrani*, though in none of our specimens is the common duct clearly visible.

Holotype male, slide 2977, Palenque, Chiapas, Mexico, 28 March 1951, in passage under ruined temple, Fairchild and Hartmann colls. Allotype female, slide 3080, same locality and collectors, 31 March 1951. Paratypes, 9♂, 8♀, same locality and habitat as holotype, 28 and 31 March 1951, all mounted on slides. In addition we have identified and stored unmounted 33♂, 1♀, from the same locality and habitat, collected 28, 29, 31 March 1951.

This species seems separable from *beltrani* Vargas and Diaz Najera on the basis of more inflated lateral lobes and shorter style with the median spine at the middle of the segment. Two males of *beltrani* were taken together with the types of *steatopygus*. Females accompanying both types of males seem indistinguishable.

Phlebotomus beltrani Vargas and Diaz Najera

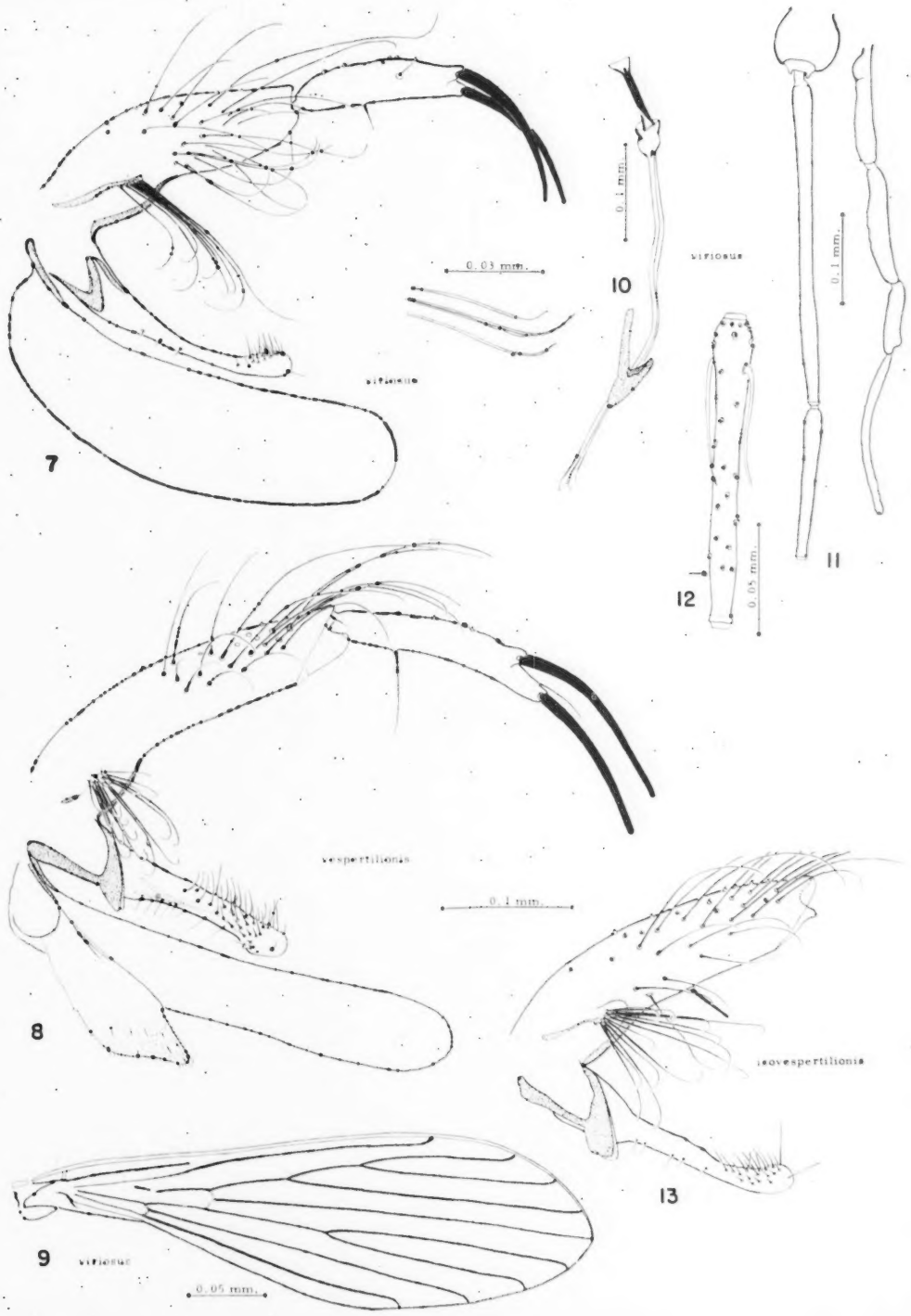
Figures 2, 14

1951, Rev. Inst. Salub. Enf. Trop. 12 (1–4): 101–103, 2 figs. (♂, San Andres Tuxtla, Vera Cruz, Mexico).

The original description and figures are rather brief and schematic, so that it may be useful to give a more extended description and figures of both sexes, based on more abundant material.

EXPLANATION OF PLATE II

FIG. 7.—*P. viriosus*, male genitalia, holotype, slide 3927, tips of genital filaments from slide 3629. FIG. 8.—*P. vespertilionis*, male genitalia, slide 1556. FIG. 9.—*P. viriosus*, male wing, holotype, slide 3927. FIG. 10.—*P. viriosus*, pump and genital filaments, paratype, slide 3956. FIG. 11.—*P. viriosus*, male basal antennal segments and palpi, holotype. FIG. 12.—*P. viriosus*, male antennal segment VII showing ascoids; arrow indicates length of female ascoids, slide 3148. FIG. 13.—*P. isovespertilionis*, male coxite and paramere, paratype, slide 1662.


0.03 mm.
7
0.1 mm.
10
vitiosus
0.1 mm.
11
0.05 mm.
12
vespertilionis
0.1 mm.
8
leovespertilionis
13
9
vitiosus
0.05 mm.

Male.—Length of wing 2.15 to 2.59 mm. Mesonotum and genitalia rather faintly infuscated. Abdominal setae mostly erect, a few semirecumbent. Upper anepisternal setae 14 to 20, lower mesanepisternals 1 to 4. Eyes small, about two-thirds of head height. Proboscis less than head height. Antennae rather long, the first flagellar segment greatly exceeding the proboscis, reaching beyond the end of fourth palpal segment on intact head, well over twice the length of the second flagellar segment. Ascoids slender, simple, as figured for *steatopygus*, paired on all but the shortened terminal segment. Palpal formula 1–4–2–3–5, the fifth segment nearly equalling the second and third together, the fourth over half the third. Pharynx slender, cibarium unarmed. Genitalia as figured; pump and filaments as in *steatopygus*.

Female.—Length of wing 2.28 to 2.36 mm. Color a little darker than in male, but still a pale sandfly. Abdominal setae mostly erect. No setae on sides of eighth segment; ninth tergite with ligulate scales. Upper anepisternal setae 13 to 23, lower mesanepisternals 1 to 4. Eyes as in male. Proboscis longer than in male but still not exceeding head height. Antennae as in male, but first flagellar segment not reaching end of third palpal segment on intact head. Ascoids as in male, though slightly longer. Palpi as in male. Newstead's scales on tip of second and apical three-fourths of third palpal segment. Pharynx broad and well sclerotized, its apex with fine ridges. Cibarium with four horizontal teeth and a strong chitinous arch, not distinguishable from other species of this group. Spermathecae as figured.

Description based on the following slide mounted material: 10♂, 2♀, Sta. Maria, Cintalapa, Chiapas, Mexico, 17 Apr. 1951, in cave with bats, Fairchild and Hartmann colls.; 2♂, Palenque, Chiapas, Mexico, 28 Mar. 1951, in passage under ruined temple, Fairchild and Hartmann colls.; 1♂, 6♀, Lancetilla valley, Tela, Honduras, 16 Sept., 29, 30 Dec. 1953, 6 Jan., 24 Mar., 21 April 1954, in light trap, W. Hils. coll.

Phlebotomus vespertilionis Fairchild and Hertig

Figure 8

1947, Ann. Ent. Soc. America 40 (4): 617–620, Pl. 1. figs. 1–7 (♂, ♀; Panama). Rosabal, 1954, Invest. Epidem. No. 3 Ministerio Salub. Pub., San José, Costa Rica, pp. 10, 28–29, figs. 55–58 (♀, Costa Rica). Rodriguez, 1946, Rev. Ecuatoriana Hig. Med. Trop. 13 (2): 80 (Ecuador).

The species we described under this name is in reality composite, consisting of two very closely similar species. Our failure to realize this resulted in our figuring one species in our description while selecting a specimen of the other species as holotype. Rearing of adults from eggs laid by isolated females has confirmed the distinctness of the two forms, but we are still unable to separate female specimens with any degree of certainty. Rosabal (1954), who worked at our Laboratory in 1951 was informed of this situation at that time. The males he noticed as not agreeing with our figure, his species No. 12, agree with the holotype of *vespertilionis*.

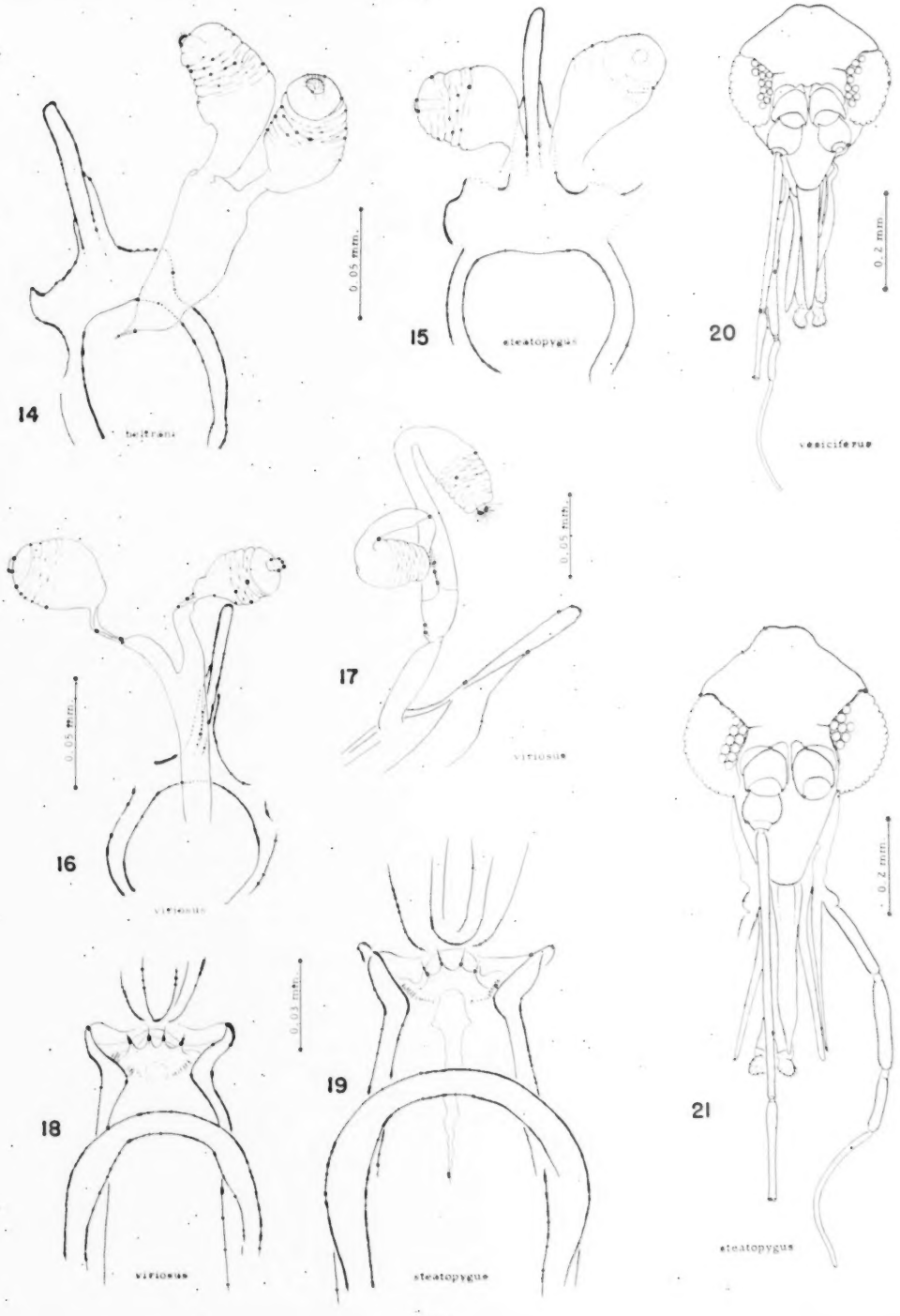
We give below a revised description of *vespertilionis* based on bred material, a formal description of the species whose male genitalia we figured in error, and a discussion of the two species.

Male.—Wing length 1.60 to 1.80 mm. Mesonotum and pleura lightly infuscated. Abdominal setae mostly or all erect; a few spine-like setae on base of seventh sternite. Upper anepisternal setae 7 to 10, lower mesanepisternals 2 to 4. Eye about four-fifths head height. Proboscis about three-fourths head height. Pharynx slender, cibarium unarmed. Third antennal segment reaching well beyond tip of proboscis, to end of fourth palpal segment on intact head, and being about twice as long as antennal segment four. Ascoids slender, simple, much shorter than their respective segments, paired on all but the last segment. Palpal formula 1–4–2–3–5, the fifth segment equalling the first three, the fourth over one-half the third. Genitalia as figured, the paramere stouter, straighter and with more setae than the following species. The basal tuft in the specimen figured has the setae pointed towards the observer so that they are somewhat foreshortened and the hooked tips exaggerated.

Female.—Wing length 1.76 to 1.93 mm. Color as in male. Abdominal setae as in male, absent on eighth tergite, ligulate on ninth. Upper anepisternals 8 to 16, lower mesanepisternals 2 to 4. Eye as in male. Proboscis slightly less than head height. Pharynx broad, well sclerotized, finely ridged at apex. Cibarium with four teeth and a strong chitinized arch, as figured by us in 1947. Third antennal segment reaching about end of proboscis and to middle of third palpal segment on intact head, about twice length of fourth segment. Ascoids slender, simple, longer than in male, but failing to reach ends of their respective segments, paired on all but the last segment. Palpal formula 1–4–2–3–5. Fifth segment equalling second and third, fourth over one-half third. Newstead's scales long and slender, on end of second and middle half of third segment. Spermathecae as figured by us in 1947.

EXPLANATION OF PLATE III

FIG. 14.—*P. beltrani*, spermathecae and genital fork slide 4506. FIG. 15.—*P. steatopygus*, spermathecae and genital fork, allotype, slide 3080. FIG. 16.—*P. viriosus*, spermathecae and genital fork, slide 4156. FIG. 17.—*P. viriosus*, spermathecae of slide 4156 drawn in phenol before mounting. FIG. 18.—*P. viriosus*, female cibarium, slide 4156. FIG. 19.—*P. steatopygus*, female cibarium, allotype. FIG. 20.—*P. vesiciferus*, female head, slide 3856. FIG. 21.—*P. steatopygus*, female head, slide 3079.


14
0.05 mm.
15
steatopygus
20
0.2 mm.
vesciferus
16
0.05 mm.
vitiosus
17
0.05 mm.
vitiosus
18
0.03 mm.
vitiosus
19
steatopygus
21
0.2 mm.
steatopygus

Phlebotomus isovespertilionis, new species

Figure 13

Phlebotomus vespertilionis Fairchild and Hertig 1947, Ann. Ent. Soc. America 40 (4): 617–620, Pl. 1, fig. 1 (in part).

Male. Wing length 1.66 to 1.89 mm. Mesonotum and pleura somewhat infuscated. Abdominal setae mostly or all erect. Upper anepisternal setae 10 to 16, lower mesanepisternals 1 to 3. Eye about three-fourths head height. Proboscis about three-fourths head height. Pharynx slender, cibarium unarmed. Third antennal segment reaching well beyond end of proboscis, to end of fourth palpal segment on intact head. Ascoids slender, simple, shorter than their respective segments, paired on all but shortened terminal segment. Palpal formula 1–4–2–3–5, fifth segment equal to or greater than sum of second and third, fourth about two-thirds of third. Genitalia as in *vespertilionis* except for more slender parameres with setae only on distal third, as here figured. Our previous figure shows far too many setae in basal tuft and tip of paramere curved toward the observer, a condition seen in many mounts.

Female.—Wing length 1.79 to 1.92 mm. Color as in male. Abdominal setae as in male, lacking on eighth segment, ligulate on ninth tergite. Upper anepisternal setae 14 to 17, lower mesanepisternals 2 to 4, all simple. Eye about seven-tenths head height. Proboscis slightly less than head height. Pharynx and cibarium as figured for *vespertilionis* by us in 1947. Third antennal segment reaching nearly to end of proboscis and to about middle of third palpal segment on intact head. Ascoids slender, simple, reaching to ends of their respective segments, paired on all but shortened terminal segment. Palpal formula as in male, fifth segment slightly less than second and third together, fourth greater than half third. Newstead's scales long, slender, clubbed, on tip of second and most of third segment. Spermathecae not distinguishable from those of *vespertilionis* as figured by us in 1947.

Holotype male, slide 6130, laboratory-reared from egg from female collected in a hollow bat tree on K–19 road on a tributary of Rio Cocoli, west side of the Canal Zone, 5 April 1956. It bears our lot number R–1093. Allotype female, slide 6135, laboratory-reared from egg from same female as holotype. Paratypes, 1♂, 7♀, bred from same egg batch as holotype; only the females mounted; 10♂, 8♀, bred from eggs from female collected at same locality 20 June 1956, lot number R–1120. Thirty-eight males from the following localities, the first 12 specimens part of the original paratype series of *vespertilionis*: 1, Barro Colorado Id., C.Z., 4 May 1947, in tree buttress; 1, La Victoria, Cerro Jefe, Panama Prov., Jan. 1947, in animal burrow; 4, Juan Mina, Chagres River, C.Z. 30 May 1944, 25 July 1945, in hollow bat tree; 3, Canal Zone Police Station, Pequeni River, Madden Lake, C.Z., 22 June 1944 in tree buttresses; 1, Cruces Trail, C.Z. Forest Reserve, 24 Jan. 1945, in bat tree; 1, Canal Zone Forest Reserve, 25 March 1945, under stones near waterfall; 1, Chiva Chiva Road, C.Z., 21 May 1944, in bat tree; 7, Cruces Trail, C.Z., 7, 18 Sept., 18 Oct. 1949, in hollow tree; 3, Cerro Campana, Panama Prov., R.P., 20 Oct. 1949, in buttresses and hollow tree; 5, Palenque, Colon Prov., R.P., 14–15 Sept. 1949, in hollow tree; 10, Rio del Medio, Rio Gatun, C.Z., 13–15 Oct. 1949, in buttresses and hollow tree; 1, La Victoria, Cerro Jefe, Panama Prov., R.P., 21 April 1951, in buttresses. In addition we have identified 322 unmounted male specimens from 16 additional localities in Panama and the Canal Zone.

The two species may be separated in the male by the shape and relative length of the parameres. The females appear to show no certain characters by which they may be separated, though averages of measurements from available bred material show that in *vespertilionis* the proboscis is slightly shorter, the third antennal segment and fifth palpal segment slightly longer than in *isovespertilionis*. Individual specimens cannot be placed on this basis, however, as there is very considerable overlapping of measurements. Based on captures of males only, there appear to be some differences in habits and habitat preferences. Thus of a total of 360 *isovespertilionis* males only 0.5 percent were taken in light traps, compared with 34.9 percent of 1170 males of *vespertilionis*. 71.9 percent of *isovespertilionis* were taken in hollow trees with bats and 24.4 percent in tree buttresses as against 35.8 percent and 17.7 percent in the case of *vespertilionis*. Only 2.2 percent of *isovespertilionis* were taken in other daytime resting places, (rock crevices) as against 11.8 percent of *vespertilionis* (rock crevices and caves). The geographical distribution in general seems to be about the same for both species, though *isovespertilionis* seems slightly less widespread and less tolerant of dryer areas. *Vespertilionis* has been taken at 43 localities in Panama, together with *isovespertilionis* at 14 and alone at 29, while we have *isovespertilionis* from an additional 9 localities unaccompanied by *vespertilionis*. We have not examined the larvae for possible distinguishing characters as yet.

NOTES ON NEOTROPICAL TABANIDAE (DIPTERA) II. DESCRIPTIONS OF NEW SPECIES AND NEW RECORDS FOR PANAMA[1]

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ABSTRACT

The *Dicladocera-Dasychela* complex is found to include a *guttipennis* group, a *unicolor* group, and a *badia* group, and species belonging in each are listed. A ruling of the International Commission seems necessary to fix the type species of *Dicladocera* Lutz and thus to determine whether this name shall be applicable to the first or the second of these groups, which appear to be at least of subgeneric value. A ruling would also be necessary to determine the validity of *Dasychela* Enderlein and its applicability to the *badia* group, which seems generically distinct. However, the synonymous *Stypochela* Enderlein, which unquestionably was validly proposed and which had line priority, is preferred here to the dubious *Dasychela*. Eleven new species, in six genera, are described and notes are given on 14 previously described species, one of which is newly reduced to synonymy.

The purpose of the present communication is to provide names for and to discuss the relationships of a number of somewhat anomalous species, mostly from northwestern South America, and to describe a species from Trinidad belonging to a group being revised by Dr. C. B. Philip. At the same time it seemed opportune to include some new species, additional records, and changes of names affecting the Panama fauna which have accumulated since 1953. Although the present additions to the Tabanid fauna of Panama raise the number of species now definitely known from the area to 121 in 18 genera, there are still too many unresolved nomenclatural tangles awaiting type comparisons to make the publication of a revised check list of much use.

The relationships and nomenclature of the group of flies variously treated as *Dasychela* End. 1922 and *Dicladocera* Lutz 1912 is complicated. The status of *Dicladocera* has been discussed by Bequaert and Renjifo (1947), Barretto (1950), and myself (1951). If, as seems probable, *Dicladocera* Lutz 1909 and 1911 with *D. guttipennis* Wied. as type is invalid, then *Dicladocera* Lutz 1912 with *D. unicolor* Lutz as type becomes the first available use of this name. *D. unicolor* however, in my opinion, is not closely related to *guttipennis* Wied., and in fact Barretto (1951) has placed *unicolor* Lutz in *Amphichlorops* on the basis of bare and unicolorous eyes. This action, however, raises a further problem, since if *Dicladocera* with *unicolor* is the first valid use of the name, and *unicolor* is in reality congeneric with *Amphichlorops flavus* Wied., the type of *Amphichlorops* Lutz 1913, then *Amphichlorops* will fall as a synonym of *Dicladocera*. However, I do not consider *unicolor* Lutz to belong in *Amphichlorops*.

The genotype of *Dasychela* End. was originally designated as *D. limbativena* End. 1922, at that time a *nomen nudum*. Enderlein (1925) described as new what is presumed to be the same species as *Dicladocera limbativena*, but with no reference whatever to his previously proposed *Dasychela*. This description of *limbativena*, based on a specimen from Colombia, appears to apply to a member of this group, though the wing pattern, and light yellowish brown color indicate a species I have not seen. Kröber (1940) gives the type locality of *Dicladocera limbativena* as "Ecuador, Cordilleren", apparently a slip of the pen, as he quotes Enderlein's description in full, followed by a description of the Ecuador specimen erroneously cited as type, pointing out certain differences between his specimen and Enderlein's, such as the longer proboscis (4.5 mm.) and somewhat different antennae. The figure accompanying Kröber's description is of the wing only, and although he does not state from which of the two specimens it was taken, it appears to agree best with Enderlein's description. Certain specimens from Ecuador before me agree quite well with Kröber's description but not with Enderlein's. These are, however, the same as *Dichelacera peruviana* Bigot, as comparison of one of them with Bigot's type in BM shows. It is to be noted that Kröber appears to have overlooked *Dasychela*, or considered it a *nomen nudum*, as it is not mentioned either in his catalogue (1934) or in his revision of *Dicladocera* (1940). Status of *Dasychela* thus seems to depend on the validity of Enderlein's 1922 proposal, where the genus is defined in a key, though its type species was a *nomen nudum*. Its use by Bequaert and Renjifo (1947) appears to be the first subsequent mention of the name.

As can be seen by the above, the nomenclatural problems are probably insoluble without recourse to a ruling by the International Commission on Zoological Nomenclature, as there does not seem to be agreement on the availability of Lutz' papers of 1909 and 1911, or on the validity of *Dasychela* End.

From a purely zoological standpoint, there appear to be a number of distinct though similar groups involved, as follows:

The *guttipennis* group. These flies have the

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labella of the proboscis membranous, or at least any small sclerotized plates are pollinose, and the labella are large, over one-third the length of the proboscis. The frons is generally broad, the callus large and prominent, usually only slightly narrower than the frons. The eyes are usually pilose, though in some species practically bare. The basicosta bears some macrotrichiae except in *guttipennis*. The wings usually have a characteristic black pattern showing a round clear fenestra in the discal cell, though in some species the pattern is much reduced and faded. With the exception of the somewhat aberrant *guttipennis* and another related species from Brasil described below, the group appears to have its center of distribution in northwestern South America, from Peru to Venezuela. I would include here, of the species I have personally examined, *macula* Macq., *basi-rufa* Walk., *submacula* Walk., *minos* Schin., *acheronitens* Kröb., and the new species described below.

The *unicolor* group. The species placed here differ from the *guttipennis* group in being less hairy, the eyes entirely bare, the basicosta always without macrotrichiae, the labella small and compact, generally well sclerotized, the frons rather narrow, the callus narrow, ridge-like, or at least with a strong upper extension, and the wings either clear or smoky, often with an indistinct pattern similar to that of the previous group. Of the species personally examined, I would place *satanica* Big., *castanea* Big., and *unicolor* Lutz here. It is probable that *barbiellini* Borgm. and *ferruginea* Barr. also would belong here. All the species of this group appear to be confined to southeastern Brasil. *Satanica*, of which I have a specimen compared with the type, is more robust and hirsute than the others, the labella larger, showing a transition in some respects to the larger species of the *guttipennis* group.

The *badia* group. These species are characterized by the elongate proboscis, often exceeding the head height, with small pollinose labella, the long and slender palpi, narrow frons with club-shaped or ridge-like callus, very slender antennae with an exceedingly long and slender dorsal projection. The eyes are generally densely pilose, rarely bare, and the basicosta is without macrotrichiae. The wings are brown on basal two-thirds with clear yellowish fenestrae surrounding the cross veins and fork of third vein (R_4), the apices being clear or smoky, or with a dilute brown discal band. I consider the following named species to belong here: *badia* Kröber, *ocellus* Walk., and *peruviana* Bigot. I believe, from the descriptions of Enderlein (1925) and Kröber (1940), that *limbativena* End. belongs here and in all probability *Stypochela bogotana* End. also. This latter species has been redescribed and figured by Kröber (1931)and seems to differ from *Dicladocera* mainly in having the suture between third and fourth flagellar segments of antennae obsolete or faint, so that the style appears three-segmented, and in having a short spur at the base of R_4. The first character probably is of little importance, while the presence of a spur vein, though unusual in this group, is not unknown, as I have several specimens of *badia* Kröb. showing a short spur in one or both wings. The other characters agree quite well, including the long proboscis, slender palpi and shape of frons. The pale color and lack of wing markings may be due to fading or a teneral condition of the specimen.

I consider the first two of these groups to be of at least subgeneric rank, while the third seems best treated as a full genus. Provisionally, and pending a decision on the availability of Lutz' 1909 and 1911 publications, it seems best to use *Dicladocera* for the *guttipennis* group as defined above, though if these publications are unavailable, *Dicladocera* will date from 1912 and shift its sense to the *unicolor* group. In either case the generic name will remain the same and a subgeneric designation can be proposed whenever the matter can be settled. In the case of *Dasychela*, the synonym *Stypochela* is available, and has, in fact, line precedence in the original 1922 proposal. *Stypochela* was unequivocally validated in 1925 by Enderlein when he described *bogotana*, its type species, so that it seems best to use this name for the *badia* group rather than the dubious *Dasychela*. Figures of the heads in side view of representatives of these three groups, and of *Triceratomyia* Beq. are included (figs. 11 to 14) to show differences in structure of proboscis.

Triceratomyia biramula, new species

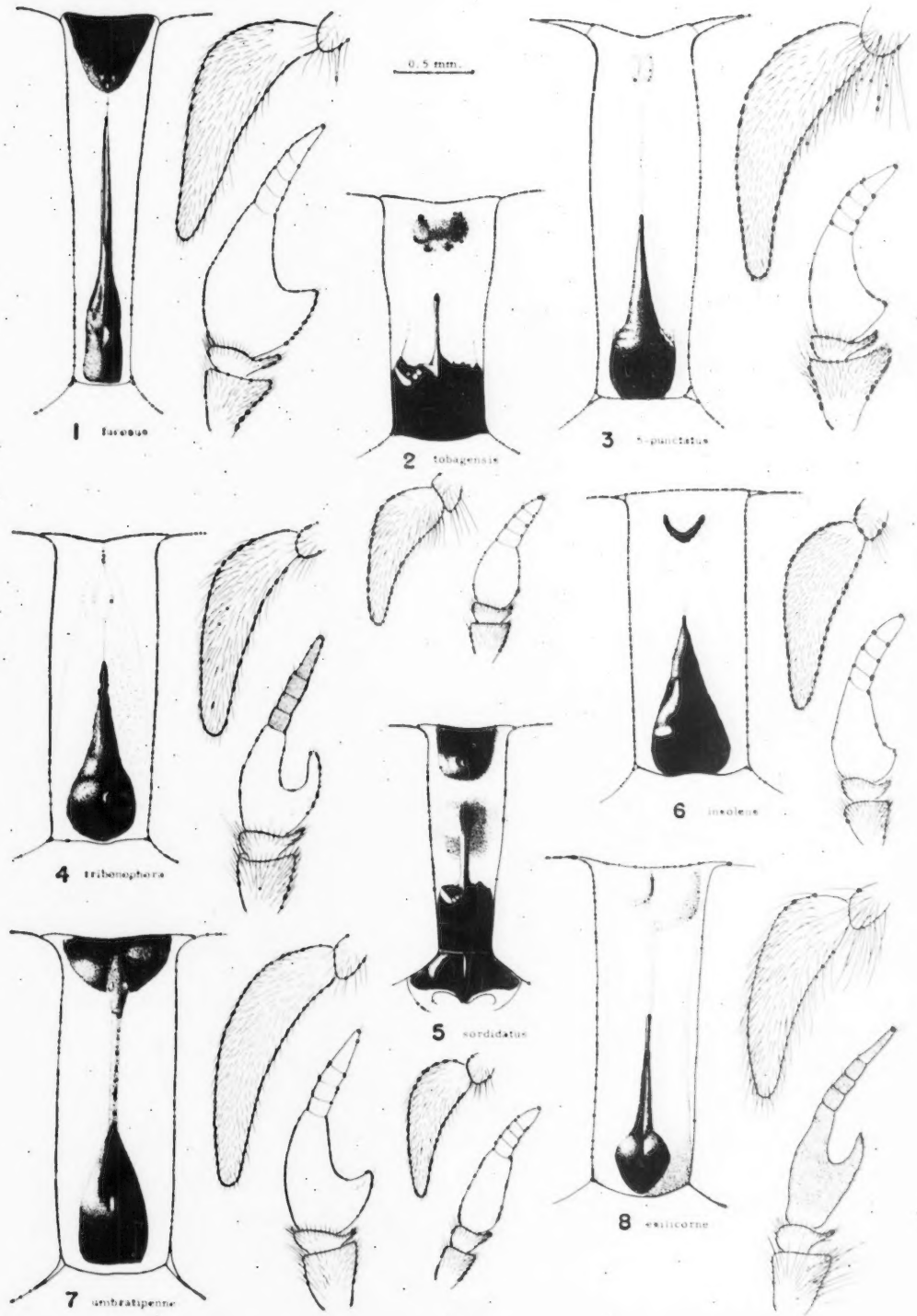
Figures 10, 11

A large brown fly with bare eyes, produced *Pangonia*-like face, proboscis over twice as long as head height, hirsute biramous third antennal segment and variegated wings.

Female.—Length 20.9 mm., of wing 18.9 mm. Eyes bare, no pattern revivable, probably unicolorous bronzy or green in life. Frons about 4.5 times as high as basal width, a little narrower in the middle, pale brown pollinose. Frontal callus brown, ridge-like, slightly enlarged and wrinkled below. No tubercle at vertex, but three dark spots in the integument which may represent vestiges of ocelli. Antennae reddish brown, the

EXPLANATION OF PLATE I

All figures are of frons, antenna and palpus and are all to the scale indicated above fig. 2. FIG. 1.—*Philipotabanus fucosus* n. sp. holotype; FIG. 2.—*Stenotabanus tobagensis* n. sp. holotype; FIG. 3.—*Tabanus 5-punctatus* Hine, homotype; FIG. 4, *Dicladocera tribonophora* n. sp. holotype; FIG. 5.—*Stenotabanus sordidatus* n. sp. holotype; FIG. 6.—*Stenotabanus insolens* n. sp. holotype; FIG. 7.—*Dicladocera umbratipenne* n. sp. holotype; FIG. 8.—*Dicladocera exilicorne* n. sp. holotype.


0.5 mm.
1 furcosus
2 tobagensis
3 4-punctatus
4 tribonophora
5 sordidatus
6 insolens
7 umbratipennis
8 vellicorne

first two segments unremarkable, clothed with dark hairs, the third segment with basal plate very deeply biramous, the lower branch bearing the 4-segmented style, which is hardly one-third the length of the basal plate, the upper branch clubbed, a little longer than the lower branch to its junction with the style, both branches with several rows of erect, fine setae on their opposing edges. Palpi very elongate, flattened, sabre-shaped, about equalling head height, brown, black-haired. Subcallus, fronto-clypeus and genae brown pollinose, the first somewhat denuded, though probably not so in fresh material, the beard brown, extending along the lower eye margin to the subcallus. Proboscis brown pollinose, slender, about twice as long as palpi, the labella small, pollinose, yellowish.

Mesonotum and scutellum reddish brown, thinly grey pollinose with a rather faint median and two pairs of sublateral pale stripes, clothed with rather long and sparse coppery hairs and with small tufts of whitish hairs just above the wing bases. Pleura and sternum pale reddish brown, yellowish grey pollinose and with pale brown hairs. Legs uniformly reddish, clothed with coppery hairs. Wings lightly fumose with the costal cell yellowish, the basal cells brown with paler centers and a broad discal brown band covering the basal halves of the marginal and submarginal cells, base of second submarginal, most of first posterior and bases of the remainder of the posterior cells, and apical half of discal cell. The extreme bases of marginal and first submarginal cells and basal half of discal cell are hyaline. There are also small yellowish fenestrae about the fork of third vein and at apex of discal cell, and fainter pale areas in the centers of cells. Venation normal, no appendix on fork of third vein. Abdomen reddish brown, subshiny, coppery haired, the first and perhaps second tergite with vestiges of greyish pruinosity. Sternites similar but paler. Halteres brown with yellow knob.

Holotype female, Cristal Mayu, Dept. Cochabamba, Bolivia, 23 November 1949, Luis E. Peña coll. In Coll. L. L. Pechuman.

This peculiar species seems quite closely related *Triceratomyia macintyrei* Beq., from which it differs most noticeably in the biramous instead of triramous third antennal segment. A figure (fig. 15) of antenna and palpus of *T. macintyrei*, from a specimen from Boayaco, Napo Pastaza, Ecuador, L. Leon coll. has been added for comparison. The other head characters and style of coloration are very similar. It is also clearly related to *Stypochela badia* Kröber, differing in bare eyes, more highly modified antennae and longer proboscis and palpi. *Stypochela ocellus* Wlk. is also close to the present species, differing structurally chiefly in lacking the rows of fine setae on the antennae and in having pilose eyes.

Stypochela peruviana (Bigot)

Figure 17

Dichoelacera peruviana Bigot, 1892, Mém. Soc. Zool. France 5: 635 (♀, Pérou).

Tabanus peruvianus, Ricardo, 1904, Ann. Mag. Nat. Hist. (7) 14: 368 (notes on type); Kröber, 1934, Rev. Ent. 4(3): 313 (not recognized).

The type in the British Museum bears a red-circled type label with "Dichelacera peruviana Bigot", a Bigot hand label with "Dichelacera peruviana ♀ n. sp. inédit Alger Mars 1890 J. Bigot Peru", a handwritten label with "Tabanus 17/7/04 G.R." and a B.M.-Bigot coll. accession label. The specimen is intact though quite dirty. A specimen from Ecuador, lacking both antennae and palpi, agreed in other respects with the type, and subsequent material agrees with this specimen and with drawings made of the type. A specimen in the Hine coll. compared by Hine with Bigot's type is *Stypochela badia* Kröb.

The species is closely related to *St. ocellus* (Wlk.) and *badia* Kröb., but can be distinguished from the former by the shorter proboscis, which does not exceed the head height, and from the latter by the more reddish tone of the integument, largely rufous-haired thorax, more contrasting wing markings, and more slender antennae. Aside from the type, the following material has been examined: 3♀, Ecuador, L. Leon coll. All lack palpi and most of antennae. 1♀, Peñaherrera, Prov. Imbabura, Ecuador, L. Leon coll. 1♀, Nanegalito, Ecuador, 27 Oct. 1956, R. W. Portman coll. 1♀, Limon, E. Ecuador, 900 M. Feb. 1948, Z. Mueller Coll. 1♀, Baños, Tungurahua, Ecuador, 1600 to 1900 M., Wm. C. MacIntyre coll. This last specimen was recorded by Bequaert and Renjifo (1947) as *Dasychela limbativena* End.

Stypochela ocellus (Walker)

Figure 16

Pangonia ocellus Walker, 1848, List Dipt. Brit. Mus. 1: 143 (♀; Quito). Kertesz, 1900, Cat. Tab. p. 22. Ricardo, 1900, Ann. Mag. Nat. Hist. (7) 5: 179 (says not *Pangonia*, belongs to the Tabaninae).

Tabanus ocellus, Kröber, 1930, Zool. Anz. 90(3-4): 86 (saw type; says *Tabanus* with head of an unknown *Fidena* species).

Dasychela ocellus, Fairchild, 1956, Smithsonian Misc. Coll. 131(3): 24.

The unique type in the British Museum bears the following labels: a green-circled label with "Pangonia ocellus Wlk.", a hand written label with "Pangonia ocellus ♀ Wlk. (Type)", a handwritten label with "S. America, Quito, presented by W. Hewitson", a white circular label with "Quito" on one side and "46/62" on the other. The head of the specimen is glued onto a card pinned separately and bearing a hand written label reading: "Head of type of Pangonia ocellus Wlk as described by Walker, but really that of *Pangoniine*, and not belonging to speci-

men. E. E. Austen 10-IV-1929". The antennae are now missing, tips of wings broken and the specimen somewhat dirty.

In spite of the remarks of Kröber and Austen, I am convinced that the head belongs to the body and that the species is a valid one. The eyes are pilose, beard cinnamon brown, as are frons, subcallus, face and palpi. Thorax reddish brown, obscurely striped, mainly with coppery red hairs; scutellum more reddish. Legs reddish brown, mainly reddish-brown-haired. Wings with basicosta bare, brownish black except for a clear band covering the apices of the basal cells and a small area about the fork of the third vein. The darkest areas are the basal cells and a band below the stigma which includes most of the discal cell. The apex of the wing and the posterior border are more greyish hyaline, though since the wings are very dirty, the markings may have been more contrasting. The abdomen is nearly black in ground color with a whitish or bluish bloom on the anterior borders of most of the tergites. There is some indication of light coppery haired hind borders to the tergites, at least on third to last tergites, but the abdomen appears to be mainly black haired.

The above description was taken from the type. Subsequent specimens from Ecuador and Peru confirm the association of head and body and permit a drawing of the antenna and palpus to be added (fig. 16). They differ very little from the type, the wing pattern being, as surmised, a little more contrasting. The Peruvian specimen is a little larger and more reddish than the two from Ecuador, its antennae slightly stouter and the wing pattern browner. Aside from the type, I have examined the following specimens: 1 ♀, Chone, Prov. Manabi, Ecuador, L. Leon coll. 1 ♀, Santo Domingo, Ecuador, 11 Nov. 1956, R. W. Portman coll. 1 ♀, Upper Rio Huallaga, Peru, 9 May 1929, H. Bassler Collection. The last two specimens were received on loan from Dr. C. B. Philip.

Dicladocera mutata, new species

This species is best described by comparison with *D. guttipennis* Wied., of which it may be only a well marked variety. The eyes, frons, callus, palpi and proboscis are as in *guttipennis*, while the antennae differ in having a shorter dorsal tooth on the base of the third segment, hardly more than a strongly produced angle. The wings, thorax, and legs are as in *guttipennis*, while the abdomen is bright orange with a black middorsal stripe instead of wholly black as in *guttipennis*. The last two visible tergites are largely blackish, somewhat orange brown only on the extreme sides.

Holotype female, Pyrenopolis, Goyaz, Brasil, 28 Aug. 1936, and 1 ♀, paratype, Pyrenopolis, Oct. 1936. To be deposited in M. C. Z.

The name was found on specimens in the Lutz collection at the Instituto Oswaldo Cruz in 1936, with which the present material was compared.

Dicladocera tribonophora, new species

Figures 4, 23

A small black species with orange antennae, a blackish band on wing with an oval hyaline spot in the discal cell and wholly black legs.

Female.—Length 11.6 mm., of wing 11.0 mm. Eyes densely pubescent, showing no evidence of pattern on revival, greenish black. Frons 3 times as high as basal width, very slightly narrowed below, dark silvery grey pollinose and with sparse erect long dark hairs. Frontal callus dark brown, portuberant, somewhat rugose, narrower than frons, extended upwards in a raised ridge nearly to vertex. No raised tubercle at vertex but vestiges of ocelli apparent in the form of three yellowish integumental spots visible through the thin pollinosity. Subcallus yellowish grey pollinose with a small cluster of erect brown hairs on each side, Fronto-clypeus and genae very thinly dark grey pollinose, clothed with long erect dark hairs. Antennae with first two segments brown, dark grey pollinose, dark-haired. Basal plate of third antennal segment bright orange, the style dark brown. Dorsal tooth short, curved, not reaching end of basal plate. Palpi moderately inflated, blunt, blackish, dark grey pollinose and black haired. Proboscis blackish, but little longer than palpi, the labella large and membranous.

Mesonotum and scutellum black in ground color except for the reddish hind margins of the former between wing bases and scutellum, all dark grey pollinose beset with erect dark hairs. Pleura and sternum slightly brownish, thinly dark grey pollinose, dark-haired. Legs very dark reddish brown, nearly black, the apices of femora a little paler, all black-haired, the hairs on hind tibiae longer, forming an indistinct fringe. Wings with basicosta with a few black setae, venation normal, no appendix on fork of third vein. Basal cells, except apices, costal cell, cubital cell and anal area, and an outwardly irregular discal band which reaches neither the fork of the third vein nor the hind margin, brown; most intense below the brown stigma, but with an oval hyaline fenestra in the distal half of the discal cell. Abdomen above subshiny, very dark blackish brown, with rather long dark hairs. The posterior margins of tergites 5 to 7 bear small median patches of yellowish hairs, while the extreme postero-lateral corners of tergites 2 to 4 bear similar hairs. The first two tergites are obscurely grey pruinose on the sides. Venter dark brown, thinly grey pruinose, dark-haired except for sparse yellow haired posterior margins of all sternites.

Holotype female, Rio Blanco, 1800 M., Oriente, Ecuador, Wm. C. MacIntyre coll. In M. C. Z. Paratype female, Nangulvi, Prov. Imbabura,

Ecuador, Luis A. León coll. The paratype has a shorter dorsal spine on antenna and slightly narrower and less prominent frontal callus.

This species bears a strong superficial resemblance to *D. guttipennis* Wied. but differs in details of wing pattern and in more densely pubescent eyes. From *D. caloptera* Schin. it differs in lacking yellow hairs on the scutellum and before the wing bases, in lacking the silver white hair patch on the fourth tergite, and in having yellow instead of black antennae, as well as in smaller size. The wing pattern is very similar to such species as *riveti* Surc., *acheronitens* Kröb., and *minos* Schin., but the species is considerably smaller than any of these.

Dicladocera umbratipenne, new species

Figures 7, 22

A stout blackish species with short antennal tooth, orange antennae, faintly marked wings, and abdomen with a bright silvery transverse band on the fourth tergite.

Female.—Length 13.5 mm., of wing 12.8 mm. Eyes densely short pilose, unicolorous greenish black on revival. Frons 3.1 times as high as basal width, practically parallel sided, light grey pollinose, becoming brownish below, rather thickly beset with erect hairs. There is also a median blackish patch only visible under light of certain incidence, and not shown in the accompanying figure. Frontal callus dark brown, shiny, smooth, drop-shaped, narrower than frons, extended above in a low ridge. Vertex black and shiny with a well marked elongate tubercle bearing three well marked vestiges of ocelli. Subcallus orange brown pollinose, with a patch of short erect hairs on each side. Antennae with first two segments brownish pollinose and with dark hairs, the third segment bright orange, the style black. Basal plate dorsally excised, the dorsal tooth short, hardly more than an acute angulate process. Fronto-clypeus and genae dark brown pollinose, clothed with rather dense and long dark hairs, the genae markedly inflated. Palpi moderately stout, blunt, blackish pollinose and with short appressed black hairs. Proboscis black, a little longer than palpi, the labella membranous.

Mesonotum and scutellum dark brown, nearly black, subshiny, clothed entirely with rather dense black hairs. Pleura and sternum dark brown, wholly dense black-haired. Legs wholly black and black-haired. Wings with costal cell strongly yellowish, stigma yellow, discal area below stigma, fork of third vein and tip of discal cell with faint yellowish brown clouds, the pattern being very similar to the wing picture of *D. submacula* Wlk., though so faint as to be hardly discernible. The main veins are also distinctly yellowish and the whole wing faintly yellowish tinged. Subepaulet with a small patch of black macrotrichiae. No appendix on fork of third vein. Halteres yellow, the stem slightly darker.

Abdomen black in ground color, the sides of first two tergites obscurely dull reddish, wholly densely black-haired except for a complete transverse band, widened in the middle, of faintly yellowish silvery hairs on the hind margin of the fourth tergite, and tufts of similar hairs on the postero-lateral margins of the second and third tergites. Beneath the abdomen is black with a broad median band of greyish pruinosity, black-haired except for sparse pale-haired hind marginal fringes on sternites 2–4.

Holotype female, Roque, Ost. And., No. 25, 8/7, Melin coll., Swedish Amaz. Exped., 1923–1925. To be deposited in the University of Lund Zoological Museum. Paratype female, Huacapistana, Rio Tarma, Peru, 1–2 June 1920. To be deposited in M. C. Z.

This species keys out with *D. steinheili* End. in Kröber's (1940) key to the species of *Dicladocera*, differing from the description of that species in shorter antennal tooth and almost wholly black body, legs and vestiture. The antennal tooth is unusually short for a member of this group, but the other structures and type of coloring and wing pattern seem to place it here.

Diclodocera exilicorne, new species

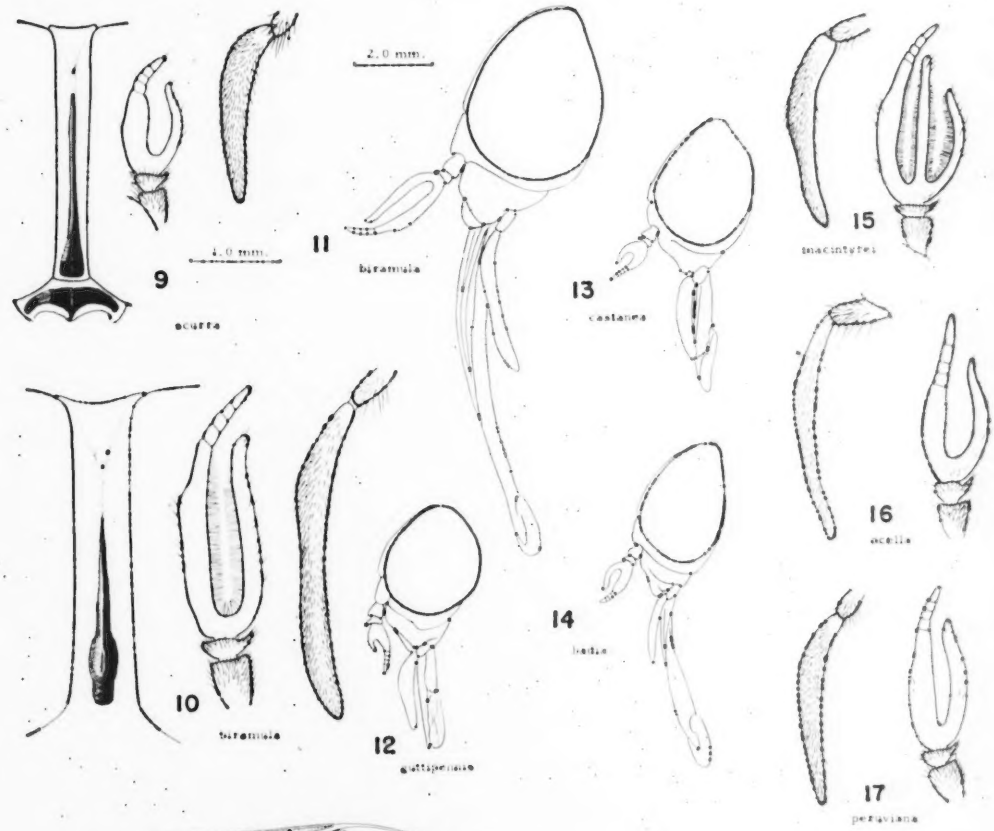
Figures 8, 20

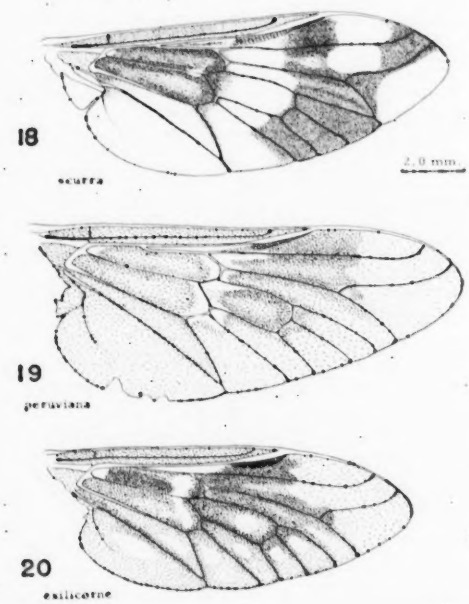
A small, hairy, blackish species with slender dark antennae, wing pattern similar to *guttipennis* Wied., and at least the third to fifth abdominal tergites broadly margined with yellow hairs behind.

Female.—Length 13.1 mm., of wing, 13.4 mm. Eyes densely and long pale pubescent, no pattern visible on revival. Frons 3.2 times as high as basal width, practically parallel-sided and quite protuberant below, dark silvery grey pollinose and with numerous long erect black hairs. Frontal callus blackish brown, heart-shaped and with a median groove, extended above in a slender hardly raised black line nearly to vertex. Vertex with a large rounded pollinose prominence or mount, without a distinct tubercle and with three faint yellowish spots representing vestiges of ocelli. Subcallus yellowish grey pollinose with

EXPLANATION OF PLATE II

Figs. 9, 10, 15 to 17 are to the scale indicated at fig. 9; figures 11 to 14 are to the scale indicated above fig. 11; figures 18 to 23 are to the scale indicated at fig. 18. FIG. 9.—*Dichelacera* (*Psalidia*) *scurra* n. sp. holotype; FIGS. 10, 11.—*Triceratomyia biramula* n. sp. holotype; FIG. 12.—*Dicladocera guttipennis* (Wied.); FIG. 13.—*Dicladocera castanea* (Bigot); FIG. 14.—*Stypochela badia* (Krob); FIG. 15.—*Triceratomyia macintyrei* (Beq.); FIG. 16.—*Stypochela ocellus* (Walk.); FIG. 17.—*Stypochela peruviana* (Bigot); FIG. 18.—*Dichelacera* (*Psalidia*) *scurra* n. sp. holotype; FIG. 19.—*Stypochela peruviana* (Big.); FIG. 20.—*Dicladocera exilicorne* n. sp. holotype; FIG. 21.—*Philipotabanus fucosus* n. sp. holotype; FIG. 22.—*Dicladocera umbratipenne* n. sp. holotype; FIG. 23.—*Dicladocera tribonophora* n. sp. holotype.


2.0 mm.
9
ocurra
4.0 mm.
11
biramula
13
castanea
15
macintyrei
10
biramula
12
guttiperosa
14
hebe
16
ocella
17
peruviana


18
ocurra
2.0 mm.
19
peruviana
20
esilicorne
21
facosus
22
umbratipenne
23
tribenophera

a patch of short, erect, brownish hairs on each side. Antennae blackish brown, the first two segments grey pollinose and with long outstanding black hairs, the third segment yellowish at extreme base, remainder blackish brown, slender, the dorsal tooth curved, acute, failing to reach end of basal plate. Style long, nearly equalling basal plate, slender, acute. Palpi moderately inflated, curved, dark grey pollinose, the first segment with long outstanding black hairs above, yellowish hairs below, the second segment with long decumbent black hairs. Proboscis short, hardly exceeding palpi, the labella membranous. Fronto-clypeus and genae faintly yellowish grey pollinose, with long outstanding mixed yellowish and dark hairs.

Mesonotum and scutellum abraded and damaged, black in ground color with the sutures and lateral margins reddish, apparently grey pollinose with indications of one or two pairs of longitudinal pale stripes and mixed reddish and black hairs. Pleura and sternum grey pollinose, rather densely clothed with mainly pale hairs intermixed with fewer black hairs. Legs dark brown, the basal halves of fore tibiae, mid tibiae and tarsi, and hind tibiae dull orange, mainly black-haired but with rufous hairs intermixed and predominating on the paler tibiae. Halteres with reddish stem and yellowish white knob. Wings with costal cell brown, first basal cell blackish except at extreme base and just before apex, second basal cell blackish except for interior of apical two-thirds. A broad blackish band covers discal area from end of stigma to hind margin, its distal border irregular with a spur including fork of third vein and its intensity lessening towards hind margin. Base of marginal cell and apex of wing greyish hyaline, and greyish hyaline fenestrae in discal cell, all posterior cells, cubital cell and anal area. By incident light the whole wing appears brown with milky whitish spots in the apices of the basal cells, middle of first submarginal cell, base of second submarginal cell, discal cell and in all posterior cells, cubital cell and anal area. Subepaulet sparsely setose, no appendix on fork of third vein.

Abdomen denuded, black in ground color with hind margins of all tergites pale, subshiny, somewhat greyish pruinose anteriorly. Vestiture apparently mostly of appressed black hairs with tufts of yellowish hairs at sides of tergites 2 to 4 and transverse yellow-haired bands, widened in the middle, on tergites 3 to 5. Venter with rather long upstanding dark hairs and indistinct pale-haired hind marginal bands on all sternites.

Holotype female, Machetes, Prov. Imbabura, Ecuador, Luis A. Leon coll. One wing mounted on a slide.

This species keys out with *D. gutipennis* Wied. and *D. nova* Kröb. in Kröber's key (1940). From the first it differs in the smaller frontal callus and more slender antennae as well as in details of color and wing pattern. From *D. nova* it differs in broader frons, shorter antennal tooth and in details of the wing pattern, as far as these can be made out from Kröber's short verbal description.

Stenotabanus (Aegialomyia) tobagensis, new species

Figure 2

A small brownish fly with unmarked wings and abdomen with median and sublateral rows of greyish spots.

Female.—Length 9.7 mm., of wing 7.8 mm. Eyes bare, in life green, with lower margin, a broad median stripe and a narrower upper stripe purple. Frons a little over 2.5 times as high as basal width, wider at vertex than at base, yellowish grey pollinose. Basal callus black, shiny, protuberant, almost as high as wide, as wide as frons, with a slender, denuded, slightly raised line reaching half way to vertex. Vertex with an irregular shiny patch but no raised tubercle nor vestiges of ocelli. Antennae short, about two-thirds length of frons, orange yellow, whitish pollinose, the first segments with black hairs dorsally, white hairs below, second segment black-haired. Style four-segmented, about equal in length to basal plate, the latter obscurely angulate dorsally. Palpi pale yellowish, white pollinose, white-haired basally and below, dark-haired elsewhere, inflated basally but with slender acute apex. Proboscis fleshy, hardly longer than palpi. Subcallus pale grey with a slightly yellowish tinge, fronto-clypeus and genae silvery grey with white hairs.

Mesonotum and scutellum cinnamon brown, brown pollinose with the anterior fourth and notopleura grey pollinose and with faint median and sublateral paler dorsal stripes, the whole thinly beset with erect black and recumbent silvery hairs. Pleura and sternum pale grey, white-haired. Legs pale yellowish brown, the tarsi darker; femora and bases of fore tibiae white-haired, rest of legs dark-haired. Wings, including costal cell, glass clear, stigma yellow, a short appendix on fork of third vein.

Abdomen light brown in ground color with the following vestiture pattern. First tergite pale brownish grey with a transverse patch of darker brown on each side; second to fifth segments with pale grey hind and lateral margins and a median pale grey patch or stripe which merges with the hind marginal band but fails to attain the anterior margin of the tergite except on the second segment. The large, roughly quadrilateral dorsolateral areas defined by the pale median patch and the posterior and lateral pale borders are cinnamon-brown-pollinose but with roughly oval paler pollinose areas in the center of each, these areas connected by a narrow neck of paler pollinosity to the pale lateral borders, and, on the fourth and succeeding tergites, to the median pale areas. The posterior and lateral margins

and the median pale patches are white-haired, the remainder dark-haired. Beneath the abdomen is pale grey pollinose, wholly pale-haired.

Holotype female, Pigeon Point Beach, Tobago Island, Trinidad, B. W. I., 1–17 July 1955, at human bait on beach, T. H. G. Aitken coll. Paratypes, 2 ♀, same data as holotype; 1 ♀, Maracas Bay, Trinidad, B. W. I., 9 March 1957, attacking man on beach, T. H. G. Aitken coll. Holotype and one paratype in coll. T. H. G. Aitken. Two paratypes to be deposited in M. C. Z.

This species is closely related to *St. littoreus* Hine, *St. blantoni* Fehld. and *St. geijskesi* Fehld. From *littoreus* it differs in narrower frons, smaller size, and in lacking a clearly defined and unbroken median abdominal pale stripe. From *blantoni* it differs in considerably narrower frons, in lacking a completely bare and shiny vertex and in narrower antennal plate, though the color and pattern of abdomen are nearly the same. From *geijskesi* it differs in more nearly parallel frons, black rather than yellowish callus, in lacking a pronounced tubercle at vertex, in less inflated palpi and more slender third antennal segment. Color and abdominal pattern are very similar, though in *geijskesi* the pale pollinose areas of the abdomen are more extensive. *St. paitillensis* Fehld. is also close, but is considerably smaller, with a more convergent frons, and with the abdominal pattern less complex and clear cut.

Stenotabanus insolens, new species

Figure 6

A small, wholly orange brown species with clear wings, the frontal callus drop-shaped and the abdomen with a broad though inconspicuous yellow median stripe.

Length 11.0 mm., of wing 9.6 mm. Eyes bare, greenish bronze, without pattern (revived). Frons about 2.5 times as high as basal width, parallel sided, rich orange pollinose with sparse recumbent orange hairs. Frontal callus orange yellow, protuberant, shiny, drop-shaped, narrower than frons, its ridge-like upper extension reaching half way to vertex. Vertex with a small V-shaped denuded spot but no tubercle nor vestiges of ocelli. Antennae shorter than frons, orange, the first two segments with orange hairs, as figured. Palpi orange, inflated, with reddish brown hairs. Proboscis brown, little longer than palpi, the labella large and membranous. Subcallus, fronto-clypeus, and genae orange pollinose, a little paler below. Beard sparse, orange.

Mesonotum, scutellum, pleura, and sternum orange brown, the last two a little paler, all orange grey pollinose with orange and brown hairs intermixed on mesonotum and scutellum. Legs orange, wholly orange-haired. Wings hyaline, the costal cell yellowish, stigma yellow, basicosta bare, no appendix on fork of third vein. Abdomen orange, brown-haired except for a broad median stripe of pale yellowish hairs on first to sixth tergites. Venter with orange hairs.

Holotype female and one female paratype, Nova Teutonia, 27° 11′ S., 52° 23′ W., Sta. Catarina Brazil, F. Plaumann coll. To be deposited in M. C. Z.

This species resembles in coloration some members of the Genus *Chlorotabanus*, but the well developed frontal callus and membranous labella exclude it from that group. It is clearly separated from other species of *Stenotabanus* known to me by the drop-shaped callus, broad frons, and wholly pale coloration. Lacking knowledge of any comparable species, I have refrained from attempting to place it in any restricted subgenus.

Stenotabanus sordidatus, new species

Figure 5

A small, wholly black-bodied species with blackish wings, white tibiae, and orange antennae.

Female.—Length 8.0 mm., of wing 8.1 mm. Eyes bare, in life purplish black with two transverse blue stripes narrowly bordered with green, the stripes narrower than the interval between them, the lower one curved upward to nearly meet the clubbed end of the upper stripe, both failing to reach the eye margin posteriorly. Frons dark brownish grey pollinose, 4.3 times as high as basal width, nearly twice as wide at vertex as at base. Callus black, shiny, protuberant, as wide as frons, markedly higher than wide, with a narrow median raised ridge extending upward and flattening out into a somewhat rugose and ill-defined median callus. Vertex largely bare and shiny, though with a narrow pollinose strip next the eye margins, and with a small discrete tubercle showing vestiges of ocelli set in a yellowish area. Subcallus slightly inflated, in the three specimens at hand largely black and shiny but with irregular vestiges of brown pollinosity suggesting that in unworn specimens this area may have been thinly pollinose. Antennae not quite as long as frons, bright orange, the first two segments black-haired. Third segment slender, the basal plate markedly longer than style. Palpi black, black pollinose and black-haired, markedly inflated. Fronto-clypeus and genae dark grey pollinose with a brownish shade along the eye margin next the subcallus, wholly black-haired.

Mesonotum and scutellum black, subshiny, with sparse erect black hairs and semirecumbent, shining, brassy, somewhat ligulate hairs. Pleura and sternum black, dark grey pollinose, sparsely black-haired. Legs black and black-haired, except basal halves of fore tibiae and mid and hind tibiae and basitarsi, which are white and white-haired. The tips of the posterior two pairs of tibiae and the tips of the basitarsi are blackish and black-haired, as are the remaining tarsal segments. Wings with costal cell dark yellowish, stigma black, subcostal and base of marginal cell (1st R)

proximal to stigma hyaline, rest of wing smoky, the marginal cell beyond stigma and first (3rd R) and second (4th R) submarginal cells amost black, the intensity of the infuscation lessening gradually towards the hind margin. Halteres dark brown, the knobs a little paler. Abdomen black, subshiny, wholly black-haired, the first two tergites slightly greenish opalescent in certain lights. Sternites wholly black and black-haired.

Holotype female, Rio Tangandi, Camp 2, Intendencia de San Blas, Panama, 25 January 1957, P. Galindo coll. This river is an eastern tributary of the Rio Mandinga, and appears on maps as Rio Sangandi. Paratypes, 1 ♀, Rio Tangandi, Camp 1, Int. de San Blas, Panama 23 January 1957, P. Galindo coll.; 1 ♀, Rio Mandinga, San Blas, Panama, 14 May 1957, P. Galindo coll. Types to be deposited in M. C. Z.

This interesting little species appears to be most nearly related to *St. constabulorum* Fchld., *St. calvitius* Fchld. and *St. vitripennis* Lutz, from all of which it can be separated by the markedly infuscated wings. All three species are similar structurally, and all have contrasting white tibiae and eyes with green or blue stripes on a purple ground. *Constabulorum* has pale pleura and narrow abdominal bands, *calvitius* a golden-haired scutellum and broad golden abdominal bands, and *vitripennis* has wholly bare and shiny fronto-clypeus and genae and golden-haired scutellum. This last species was described as a *Diachlorus*, and is perhaps annectant to that genus, but the eye pattern, though rather unique, and the lack of a pearly patch on the pleura, as well as other structural characters, seem to necessitate its placement in *Stenotabanus*. I saw the type of *vitripennis* in 1936 and noted that it was entirely distinct from *Diachlorus paradoxus* Lutz, under which Bequaert (1926), relying on the description, placed it as a synonym.

Philipotabanus fucosus, new species

Figures 1, 21

A black species with large black discal patch on wing, thorax striped with orange-red hairs, and fourth abdominal tergite with a large silvery white patch.

Female.—Length 13.5 mm., of wing 12.5 mm. Eyes bare, unicolorous greenish black on revival. Frons 6 times as high as basal width, 1.5 times as wide at vertex as at base, light grey pollinose and with rather dense erect dark hairs on upper third. Frontal callus black, rugose, narrower than frons, about 2.5 times as high as wide, extended above in a bare ridge nearly to vertex. Whole vertex subshiny, swollen, produced onto frons in a narrow raised triangle whose apex bears vestiges of three ocelli. Subcallus pale yellowish grey pollinose with a small patch of short fine erect hairs on each side. Antennae dark brown, the first two segments with dense short appressed black hairs, the third segment with the wide basal plate reddish at base, dusky at apex and with a strong dorsal angle. Style shorter than basal plate, dark brown. Fronto-clypeus and genae dark grey pollinose, the hairs next the eye margins and subcallus dark, the beard nearly white. Palpi moderately inflated, blackish pollinose and black haired. Proboscis black, but little longer than palpi, the labella large and membranous.

Mesonotum and scutellum dark reddish brown in ground color, the sutures paler, reddish, thinly brownish grey pollinose. Scutellum except base, lateral margins of mesonotum and a pair of broad sublateral stripes orange-red-haired, the remainder black-haired. Pleura and sternum dark grey pollinose, pale grey-haired. Legs dark brown, nearly black, wholly black-haired. Wings with basicosta less densely setose than costa, no appendix on fork of third vein. Costal cell dilute brownish, darker proximal to humeral vein. Basal cells and base of marginal cell hyaline, the veins bordering this area reddish, dark elsewhere. A large black patch covers the discal area, including discal cell, from ends of basal cells to beyond fork of third vein, its outer and posterior margins being irregular and failing to reach hind margin of wing. Cubital cell and anal area heavily infuscated.

Abdomen dark brown in ground color, the first and sides of second tergites grey pruinose, as is the middle of fourth tergite. Sides of first and second tergites and a large trapezoidal patch on middle of fourth tergite white-haired, otherwise tergites all black-haired. Sternum paler, grey pruinose, dark-haired except for white-haired hind margins of sternites 2 to 4.

Holotype female, El Retiro, Villavicencio, Intendencia de Meta, Colombia, 12 Jan. 1942, M. Bates coll. Paratype female, Villavicencio, Meta, Colombia, 12 Jan. 1942, M. Bates coll. Types to be deposited in M. C. Z.

This species approaches in a number of respects the descriptions of such species as *caloptera* Schin, *nigripalpis* Macq. and *rufescens* F., differing chiefly in lacking a long dorsal tooth on antennae. These species have generally been placed in *Catacholorops* or *Dicladocera*, but until authentic specimens can be studied to determine the condition of the basicosta, proboscis, etc. their status will remain uncertain. *Fucosus* appears to be closely related to *Philipotabanus inauratus* Fchld. differing from that species in lacking the brilliantly golden-haired scutellum, in broader frons and in having the black discal patch of the wing less extensive.

Dichelacera (Psalidia) scurra, new species

Figures 9, 18

A large, orange brown species with bare subcallus, bare patches on face, and boldly black marked wings.

Female.—Length 16.4 mm., of wing 14.0 mm.

Eyes bare, greenish purple, without bands (revived), possibly bright green in life. Frons 6.4 times as high as basal width, nearly parallel-sided, orange pollinose and with sparse, short, orange yellow hairs. Frontal callus orange brown, below rugose and with a median vertical groove, not as wide as frons, extending above to tubercle at vertex in the form of a strongly raised bare ridge, only the last sixth of which is covered with pollen. Tubercle at vertex inconspicuous, pollinose, with faint vestiges of ocelli. Antennae bright orange, the first two segments clothed with orange hairs, the dorsal tooth long, reaching well beyond end of basal plate, as figured. Subcallus somewhat inflated, largely bare, wrinkled, thinly pollinose at margins. Fronto-clypeus and genae thinly orange pollinose, sparsely orange-haired, and with a bare shiny patch above the insertion of the palpi on each side. Palpi orange, orange-brown-haired, moderately slender, about equalling antennae in length. Proboscis reddish brown, longer than palpi, the theca and labella wholly shiny sclerotized.

Mesonotum, scutellum, pleura and sternum dark orange brown, the last two with slightly greyish pollinosity and orange hairs, the dorsum with sparse erect brown hairs and semirecumbent orange yellow hairs. Legs wholly reddish orange with orange yellow hairs. Wings with costal cell orange brown, both basal cells dark brown and with a dark brown fascia extending from apex of stigma to anterior border of fifth posterior cell (1st. Cu), thence filling wing to posterior margin up to apex of closed first posterior cell (5th R), and extending along upper fork of third vein (R_{2+3}) to fill apical fourth of first submarginal cell (3rd R) and apex of marginal cell (1st R), leaving a large patch in middles of marginal and first submarginal cells, and most of second submarginal cell (4th R) hyaline. The hyaline areas are not tinged with yellow except slightly just below the yellow stigma and in apex of costal cell. First posterior cell closed and petiolate in holotype and one paratype, closed at margin in remaining paratypes. Abdomen wholly orange brown, orange-haired, the venter slightly paler. Two paratypes have the apical hyaline areas smaller than in the other specimens.

Holotype female and two female paratypes, Pacora, Panama Province, Panama, 14 January 1953, Station B, ground level, attacking man, F. S. Blanton coll. Two female paratypes Rio Tuira Yellow Fever Sta., Darien Prov., Panama, 25 Feb., 1 March 1958, in Shannon trap, Galindo coll. To be deposited in M. C. Z.

This species differs from *D. fulminea* Hine in stouter palpi as well as in wing pattern, notably the entirely dark basal cells. From *D. victoria* Fehld. it can be separated by the bare subcallus, longer antennal tooth and wholly dark basal cells. *D. bahiana* Fehld. has the second basal cell hyaline, the wing intensely yellow and the antennae and palpi very much more slender. *D. fairchildi* Barr. lacks the clear areas in the marginal and submarginal cells and the whole wing pattern is more diffuse. *D. beameri* Philip differs in having the basal cells wholly yellow.

Tabanus (Lophotabanus) polyphemus, new species

Tabanus (Lophotabanus) fumomarginatus, Fairchild, 1951, Ann. Ent. Soc. America 44(3): 455-456, figs. 7, 7a, 7b. Not *Tabanus fumomarginatus* Hine 1920.

Dr. C. B. Philip was kind enough to compare the specimen figured as *fumomarginatus* Hine by me in the reference cited above with Hine's types and found it was not in agreement. My previous determination was based on Hine's description together with sketchy notes on the types made some years before. To avoid further confusion, this same specimen is taken as the holotype of *polyphemus* n. sp.

A fairly large dark brown species with large and prominent scutellar black spot, fumose wings with the veins more or less clearly brown margined, orange antennae and small orange-haired middorsal abdominal triangles.

Female.—Length 20 mm., of wing 17.5 mm. Eyes bare, in life bicolored, the lower two-thirds green, the upper third bronzy, the line of demarkation between the colors sharp. Revived, the eye shows no pattern. Frons about six times as high as basal width, slightly wider at vertex, orange-brown pollinose and with short recumbent orange hairs and, especially at vertex, short, erect, black hairs. Frontal callus small, orange-brown, long oval, narrower than frons, rather flat and rugose and with a median groove, the upper prolongation a brown ridge reaching two-thirds the distance to the vertex. Vertex without vestiges of ocelli, but with a slightly raised paler subshiny area. Subcallus orange grey pollinose, paler than frons, without hairs. Antennae reddish orange, the first segment strongly produced above, clothed with mixed yellow and dark coppery red hairs. Third segment with a strong dorsal angle, reddish orange, pale pollinose, the style dusky. Palpi moderately inflated with slender apex, yellowish, pale pollinose and with dense appressed golden coppery hairs. Fronto-clypeus and genae orange grey pollinose, beard pale reddish yellow. Proboscis brown, exceeding palpi, labella membranous.

Mesonotum dark brown in ground color, greyish brown pollinose with a faint slender median and a pair of slender sublateral darker stripes, clothed with mixed black and coppery red recumbent hairs. Scutellum and prescutellum black, densely black-haired, the former with pale pollinose and white-haired lateral and posterior margins, the former with a pair of diagonal white and white-haired stripes before it which just fail to meet in the midline, so that the black scutellar spot is almost completely ringed with white.

Legs orange red, the tarsi darker, femora and tibiae coppery red-haired, the tarsi black-haired and some black hairs on anterior aspect of fore femora and tibiae, especially distally. Wings with basicosta setose, no appendix on fork of third vein, first posterior cell a little narrowed, whole wing smoky, more intense in costal cell and along veins. Stigma brown.

Abdomen reddish brown in ground color, thinly yellowish brown pruinose, clothed mainly with dark coppery red hairs, but with considerable admixture of black hairs dorsally. Tergites 1 to 4 bear small median triangles of dark yellow hairs, and there are small remnants consisting of a few paler hairs on tergites 5 and 6. Beneath the abdomen is wholly red-haired, except for a median patch of long erect black hairs on the last sternite.

Holotype female, La Victoria, Cerro Jefe, Panama Prov., Panama, 16 May 1950, Yellow Fever Sta. B. Paratypes: 1 ♀, same locality as holotype, 6 May 1950; 1 ♀, Cerro Azul near Pacora, Panama, 2100 ft., no date. 10 ♀, Lancetilla, Tela, Honduras, 21 May 1954 and 1, 3, 10 and 20 July, 1953, all taken attacking man in the forest canopy, from 41 to 89 feet above ground level; 2 ♀, Rio Polochic, Alta Vera Paz, Guatemala, 14 May 1956, J. Boshell and J. Bevier colls.; 5 ♀, Teapa, Tabasco, Mexico, July-Aug. 1953; 1 ♀, Coatzacoalcos, Vera Cruz, Mexico, 2 Aug. 1953; 3 ♀, Rio Tuira, Darien Prov., Panama, 26, 27 April 1958; 1 ♀, Rio Paya, Darien Prov., Panama, 24 April 1958; 1 ♀, Colombia, S. A., 1926, in coll. L. L. Pechuman.

The paratypes vary from 16.6 mm. to 21.9 mm. in body length and from 15.0 mm. to 19.2 mm. in wing length, the smallest being from Panama, the largest from Honduras.

The species appears to differ from the descriptions of *fumomarginatus* Hine in having orange antennae and yellow-haired middorsal abdominal triangles. *T.* (*Lopholabanus*) *defilippii* Bell. is also very similar in appearance but may be separated by the wholly black-haired abdomen, more slender black-haired palpi, longer antennal tooth, ridge-like frontal callus and orange-haired posterior margin of scutellum. *T.* (*L.*) *jilamensis* Hine is smaller, the pale palpi black-haired, the legs pale except for black fore femora and bicolored fore tibiae, the scutellar spot smaller and surrounded by pale brownish hairs, and the abdomen with a pale middorsal stripe.

Fidena gracilis (Kröber)

Melpia gracilis Kröber, 1931, Mitt. Zool. Staatsinst. u. Zool. Mus. Hamburg 44: 181 (♂, ♀; Brasilien; Columbien, Chiriqui).

Fidena gracilis, Kröber, 1934, Rev. Ent. 4(2): 247. Bequaert and Renjifo, 1947, Psyche 1946, 53(3–4): 60 (Restrepo, Villavicencio, Pasto, Colombia). Fairchild, 1941, Ann. Ent. Soc. America 34(3): 655, figs. 3, 3a, 3b (Colombia); 1953, Ann. Ent. Soc. America 46(2): 262 (in key). Philip, 1954, Rev. Brasil. Ent. 2: 25 (in key).

Kröber (1931) states that his types were from Brasil and in Halle. As pointed out by Bequaert and Renjifo, Chiriqui is in western Panama, not Colombia. Specimens from Colombia determined by Bequaert and figured by me do not agree in some minor respects with Kröber's description, and it is possible that Kröber's Brazilian specimens are in reality a different species, but in the absence of figures no certainty is attainable without comparison with his types. It seems best, however, to retain the use of *gracilis* for the Colombian specimens recorded by Bequaert and Renjifo (1946) and figured by Fairchild (1941). Although included by Fairchild (1941, 1942) in the Panama fauna on the strength of Kröber's reference, no actual Panamanian specimens had been seen. We can now record four females from the Rio Mandinga, on the border between Colon Province and the Intendencia of San Blas, 16, 17, and 19 May 1957, all taken at human bait in the forest canopy by my colleague Pedro Galindo, and one female, Rio Tuira Yellow Fever Sta., Darien Prov., Panama, 20 May 1958. The Rio Mandinga specimens are smaller and blacker than Colombian material, the face slightly more produced, the palpi more slender than shown in my figure, while the Darien specimen is as large as Colombian examples. A specimen from Tingo Maria (Rio Huallaga), 700 M., Peru, 1940, Weyrauch coll. has also been seen. It is indistinguishable from Colombian examples from Villavicencio.

Fidena auribarba var. albibarba (Enderlein)

Melpia auribarba var. *albibarba* Enderlein, 1925, Mitt. Zool. Mus. Berlin 11(2): 276 (♀; Columbia). Kröber, 1931, Mitt. Zool. Staatsinst. u. Zool. Mus. Hamburg 44: 176, fig. 26.

Fidena auribarba var. *albibarba*, Kröber, 1934, Rev. Ent. 4(2): 255.

Melpia columbiensis Kröber, 1931, Mitt. Zool. Staatsinst. u. Zool. Mus. Hamburg 44: 177 (♀; Colombia).

Fidena columbiensis, Kröber, 1934, Rev. Ent. 4(2): 247. Bequaert and Renjifo, 1947, Psyche [1946] 53(3–4): 61. Fairchild, 1951, Ann. Ent. Soc. America 44(3): 442 (♀; Panama). Philip, 1954, Rev. Brasil. Ent. 2: 25–26. Fairchild, 1956, Smithsonian Misc. Coll. 131(3): 13.

Dr. Philip and I compared Panama specimens with Kröber's type of *columbiensis* in the British Museum in 1953 and found them to agree. Later Dr. Philip was able to compare the same specimens with Enderlein's type of *auribarba* var. *albibarba* and found equally close agreement (letter of 23 Dec. 1955). He did not see the type of *auribarba* End. There is also another *Fidena albibarba* of Enderlein (1925, Mitt. Zool. Mus. Berlin, 11(2): 293) from Southern Brazil, but the present species has page priority, and Dr. Philip informs me that this second *albibarba*, which is not listed in Kröber's Catalogue, is the same as *F. leucopogon* Wied. Aside from the specimens previously discussed (Fairchild 1951), I have now seen 1 ♀, Almirante, Bocas del Toro Province, 30 Sept. 1951, and 14 ♀ taken in the treetops at a

station along the Calderas-Chiriquicito trail, Chiriqui Prov., 26 Oct.–5 Nov. 1955. The locality was said by the collector to be in very wet montane forest. Whether the species is in reality only a variety of *auribarba* End. can only be ascertained by careful type comparison.

Philipotabanus fascipennis Macquart

Tabanus fascipennis Macquart, 1845, Dipt. Exot., Suppl. 4, p. 35, Pl. 4, fig. 4 (♀; New Granada).
Tabanus (*Phaeotabanus*) *fascipennis*, Kröber, 1930, Zool. Anz. 86: 278, figs. 1, 1a (♀; Bogota, Venezuela); 1934, Rev. Ent. 4(3): 305.
Tabanus (*Philipotabanus*) *fascipennis*, Fairchild, 1943, Ann. Ent. Soc. America [1942] 35(4): 462, fig. 19 (♀; Venezuela). Becquaert and Renjifo 1947, Psyche [1946] 53(3–4): 82. Fairchild, 1956, Smithsonian Misc. Coll. 131(3): 16.

The type in the British Museum is in poor condition, lacking antennae and being crushed and dirty. It is labelled "Nov. Granata Macq. D. Exot". Another specimen also from the Bigot collection is labelled "Bogota" and probably forms the basis of Kröber's (1930) record. A well preserved specimen from La Zumbadora, Cerro Azul, Panama Prov., Panama, 4 Feb. 1947, is an addition to the Panama fauna. The eyes are unbanded, bright green in life. The mesonotum and scutellum are brown, with mixed black and coppery hairs, the latter forming indistinct stripes on mesonotum and clothing the scutellum rather densely. Legs entirely black. Abdomen jet black, black-haired except for a small white-haired triangle on fourth tergite and sparse white hair tufts on sides of tergites 1–3. Beneath the sternites are thinly greyish pruinose, the second to fourth sternites with sparse white-haired hind marginal bands, otherwise black-haired. The black wing markings are very intense and with a bright blue reflection in light of suitable incidence. The head characters are as figured previously (Fairchild 1942)

Tabanus quinquepunctatus Hine

Figure 3

1925, Occ. Papers Mus. Zool. Univ. Michigan No. 162: 33. Change of name for *T. quinquemaculatus* Hine 1907.
Tabanus quinquemaculatus Hine, 1907, Ohio Nat. 8(2): 224 (♀; Morales, Guatemala; type in Ohio State Univ. Museum). Not *T. quinquemaculatus* Hine 1901.

Kröber (1934) does not list *quinquepunctatus*. I have a specimen (Stann Creek, British Honduras, 19 June 1940, W. H. Komp coll.) which I compared and found to agree with Hine's type in 1940. Agreeing with this specimen are 4♀, El Valle, Coele Prov., Panama, 6 Jan. 1954, taken in light trap; 3♀, Boquete, Chiriqui Prov., Panama, 24–25 March, 1954, light trap; 1♀, Concepcion, Chiriqui Prov., Panama, 9 Dec. 1952, light trap. The specimens represent a considerable extension of range for the species and an addition to the Panama fauna. The taking of the species only in light traps suggests at least crepuscular habits. Since the species has not previously been figured, figures are here given of frons, antennae and palpi. Hine's description, though brief, covers the salient points of color and pattern.

Stenotabanus maruccii Fairchild

1947, Ann. Ent. Soc. America [1946] 39(4): 568, fig. 8 (♀; San Blas, Panama).
Stenotabanus frondicolus Fairchild, 1951, Ann. Ent. Soc. America 44(3): 453–454, fig. 5 (♀; Chiriqui, Panama); 1953, Proc. Ent. Soc. Washington 55(5): 241. *New synonymy.*

Comparison of specimens of *frondicolus* with the type of *maruccii* in M. C. Z. in 1953 leaves no doubt of the above somewhat embarassing synonymy. The differences pointed out in the description of *frondicolus* are of minor degree only and have proven to be well within the range of individual variation. The species is fairly abundant in the forest canopy at Almirante, Bocas del Toro Prov., on the upper Rio Mandinga, Intendencia de San Blas, and a few specimens have been taken at La Zumbadora, Cerro Azul, Panama Prov. Dates of capture indicate it is on the wing practically throughout the year, almost entirely in the forest canopy.

Stenotabanus calvitius Fairchild

1942, Ann. Ent. Soc. America 35(3): 306–307, fig. 10 (♀; Panama City, Panama).

A specimen from Rio Tanganti, Rio Mandinga, Int. San Blas, Panama, 24 Jan. 1957, P. Galindo coll., represents the second known specimen of this little species. It agrees closely with the original description, though the type is not now before me.

Philipotabanus stigmaticalis Kröber

1931, Stettin. Ent. Zeit. 92: 299 (♂; Santarem, Brazil). Fairchild, 1956, Smithsonian Misc. Coll. 131(3): 29.
Tabanus (*Philipotabanus*) *grassator* Fairchild, 1953, Ann. Ent. Soc. America 46(2): 278–279, Pl. 2, fig. 9 (♀; Almirante, Panama).

Kröber's type in London was headless on examination in 1953, labelled "Brasil, Santarem, W. H. Bates, 52–69". Another specimen exactly agreeing with type of *grassator* was taken along the Calderas-Chiriquicito trail, Chiriqui Prov., Panama, in treetops somewhere between 600–1400 ft., 26 Oct.–5 Nov. 1955. A female labelled "British Guiana, Cattle trail survey, Takaruni R. (sec. 2), June 1919, A. A. Abraham coll." is smaller and darker than Panama specimens, but does not seem to differ structurally. It is to be noted that two of the four known specimens of this species were taken in the treetops.

Tabanus praeteritus Fairchild

1947, Ann. Ent. Soc. America [1946] 39(4): 570–572, figs. 6, 6a (♀, ♂; Panama).

This species has proven to be quite abundant on the Atlantic side of the Canal Zone, long series having been taken in horse-baited mosquito stable traps at France Air Force Base, Coco Solo, the Navy Tank Farm, Ft. Gulick, and Gatun.

mainly during the dry season months from January to May.

Tabanus praepilatus Fairchild

1943, Ann. Ent. Soc. America [1942] 35(4): 445, fig. 11 (♀; Panama); 1947, Ann. Ent. Soc. America. [1946] 39(4): 569.

The male is easily associated with the female on color and pattern and by the structure of the antennae. Eyes bare, holoptic, the large facets sharply differentiated in size from the small, but no sharp line of demarkation between the two types, the large facets occupying over two-thirds of the eye area. Vertex with a small tubercle. Frontal triangle orange-grey pollinose. Antennae dark brown, more slender than in female, the style longer than basal plate. Palpi porrect, pale yellowish, oval; pointed, white-haired. Thorax, legs and wings as in female. Abdomen long and pointed, with a median row of pale-haired triangles and a dorsolateral row of oblique pale spots, as in female but the ground color paler brown and the light markings more extensive and diffuse.

Allotype male, Garachine, Darien Prov., Panama, 22 Feb. 1953, light trap. The head has been glued on and one antenna is missing.

Additional locality records are: 5 ♀, Tonosi, Los Santos Prov., Panama, 5 May 1949, in mangrove swamp, P. Galindo coll.; 1 ♀, Panama City, Panama, 25 April 1951; 1 ♀, Garachine, Darien Prov., Panama, 16 Feb. 1953, light trap. The species appears to be confined to coastal mangrove swamps along the Pacific coast of Panama.

Tabanus nereus Fairchild

1943, Ann. Ent. Soc. America [1942] 35(4): 446, fig. 9 (♀; Panama).

Further material indicates this to be a coastal species flying mainly during the rainy season. 1 ♀, Old Panama, 26 Sept. 1952, in light trap; 5 ♀, Puerto Chitre, Herrera Prov., Panama, 24 Oct. 1952, in light trap; 5 ♀, Jaque, Darien Prov., Panama, 24–25 July, 1952, in light trap.

Tabanus rixator Fairchild

1943, Ann. Ent. Soc. America [1942] 35(4): 448, fig. 10 (♀; Panama).

This species is showing a confusing amount of variation, with additional material, and may eventually prove to be composite. The type and another specimen from Paitilla Point, near Panama city show a more or less drop-shaped frontal callus, as figured previously, and a rather well marked yellowish median abdominal stripe. Specimens from Old Panama, (April and June, 1949) less than a mile away and also on the coast, have the callus oblong and often with the median upper prolongation unattached, forming a small median callus. The abdomen bears a median row of narrow continguous triangles and a dorsolateral pair of rather broad yellow-haired stripes. Material from Patiño Point, Darien, July and August 1952, taken in light trap, and a single old but well preserved specimen labelled "Panama, R. Paessler leg. 31. VII–10. VIII 1907" in M. C. Z. are like those from Old Panama, except that the dorsolateral stripes are narrower and less distinct. Specimens from Ft. Kobbe, C. Z., February and April, 1953 are somewhat rubbed, but seem to be like those from Old Panama. Three specimens from San José Island, in Panama bay, and one from Chame, 3 April, 1951 are apparently also the same. Sizes range from 10.9 mm. to 13.8 mm. Proportions of frons, shape and color of palpi and antennae in all these are closely similar. It is possible that two species with similar ranges exist, one flying in the dry season, the other in the rainy season, but much more material is necessary to prove this.

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THE GENUS FARULA (TRICHOPTERA: LIMNEPHILIDAE)[1]

D. G. DENNING

ABSTRACT

The rare caddisfly genus is probably placed correctly in the subfamily Dicosmoecinae, but the unusual complexity of the male genitalia makes its relationships to to other genera difficult to determine. The four known species occur in the coastal mountainous regions of Oregon and Washington; of these, *F. jewetti* and *F. davisi* are described as new. A key to the males is given. Females of *F. jewetti* only are known.

When the genus *Farula* was established by Milne (1936) to accomodate the new species *vainieri*, it was placed in the Sericostomatidae. This genus and *Neothremma* Banks were properly removed to the Limnephilidae by Ross (1944), who later (1950) observed that these genera are similar to one another in general appearance. Schmid (1955) has probably placed *Farula* correctly in the subfamily Dicosmoecinae, along with such similar genera as *Lepania* Ross, *Imania* Mart., and *Ecclisomyia* Banks.

The male genitalia of *Farula* have undergone so many secondary modifications that they present a very unusual and complex structure. Largely because of this complexity, its relationships to other genera are questionable. In some respects the genitalia are similar to those of *Neothremma*, *Lepania*, and *Radema*. Schmid (1955) compared the specialization of the genitalia to that in members of the Goeridae, such as *Goera vulpina* Hagen and *G. riumabia* Mosely. It is interesting to note that the well-known European trichopterist Nielsen (1957) suggested placing the Goeridae as a subfamily of Limnephilidae; on the basis of the morphology and biology of the larvae and the structure of the male genitalia, the subfamily Goerinae is closely related to the Apataniinae (Limnephilidae). In this paper the first known female in the genus is described; its general appearance and genitalia bear the closest resemblance to those of *Neothremma*. Without doubt, *Farula* is one of the most specialized and one of the most curious genera in the family.

Along with such limnephilid genera as *Imania*, *Moselyana*, *Lepania*, and *Rossiana*, the genus *Farula* is also one of the rarest in North America, and only a few specimens have been collected. Previously only the holotypes of *F. vainieri* and *F. malkini* were available. With this paper the known species are doubled, to four, and the total specimens now available in collections are six males and three females. Species of *Farula* have been collected only in the coastal mountainous regions of Washington and Oregon, but the genus will, in all probability, be found in British Columbia and northern California.

The generic description of *Farula* by Schmid (1955) was based only on the holotype of *F. vainieri*. The following description is condensed and modified to include the four species now known.

Genus **Farula** Milne 1936

Ventral part of head bulbous; eyes small; antennae about as long as wings; maxillary palpi of male porrect, shorter than labial palpi, first and second segments about equal in length, third usually longest. Mesoscutellum long, approximately half as long as metanotum, bearing a single elongate wart. Head with vertex raised above eyes; ocelli distinctly tuberculate. Legs with spur count 1-2-4.

Fore and hind wings similar, long, narrow, rounded at apex. Fore wing with discoidal cell located in the center and much shorter than its petiole; M_{3+4} absent; thyridial cell long and narrow, about three times as long as its petiole; basal portion of A_3 atrophied. Hind wing with discoidal cell subbasal in position; Cu two-branched and parallel.

Genital armature composed of four pairs of appendages, the most dorsad pair short and stocky in lateral aspect, second pair acute and filamentous, third pair forming an irregular, heavily sclerotized structure with an acute lateral angulation, fourth pair elongate, slender, approximately the same width throughout. In one species (*F. malkini*) a fifth, filamentous, process arises from the base of the clasper. Claspers narrow, elongate, tapering to a narrow apex.

The most dorsad pair of appendages may represent the dorsal lobes of the ninth tergite, the second pair its ventral lobes, and the third pair may represent the tenth tergite. The homologies of the fourth pair of appendages are uncertain, but these may represent a lateral process of the claspers. The terminology in the key below is based on these identities. In the specific descriptions that follow, the same lettering is used as that employed by Ross (1950) in describing the complex male genitalia.

Key to the Species of Farula

1. Clasper with a slender filamentous process arising from base and extending considerably beyond apex ..... **malkini**
   Clasper without such filamentous process 2

[1]Accepted for publication March 15, 1958.

2. Apex of ventral lobes of ninth tergite hooked sharply laterad at apex; dorsal lobes of ninth tergite divergent, widely separated . . . . . **rainieri**
Apex of ventral lobes of ninth tergite knobbed, or only slightly directed laterad; dorsal lobes of ninth tergite closely parallel or bearing a dense brush of spines 3
3. Apex of ventral lobes of ninth tergite knobbed; dorsal lobes of ninth tergite bearing a dense brush of spines . . . . . **jewetti**
Apex of ventral lobes of ninth tergite turned slightly laterad; dorsal lobes of ninth tergite quite closely appressed . . . . . **davisi**

Farula malkini Ross

Farula malkini Ross, 1950: 421, fig. 11, ♂.

The original male was collected at Mary's Peak, Benton County, Oregon, elevation 2100 feet, May 4, 1947, by B. Malkin and M. J. Sargent. This holotype is in the Illinois Natural History Survey collection. A second male was taken recently in the same general locality and bears the following collection data: Parker Creek Falls, Mary's Peak, Benton County, Oregon, 3500 feet, June 9, 1957, Borys Malkin.

The second male agrees very closely with Ross' description and figures (see fig. 1), and only a few details need be added. The third segment of the maxillary palpi is longer than either the first or the second, and in this specimen the palpi are porrect. Ross described the wings of his male type as milky colored, probably due to the teneral condition of the specimen. This second male also has the wings milky colored, with a uniform scattering of black hairs.

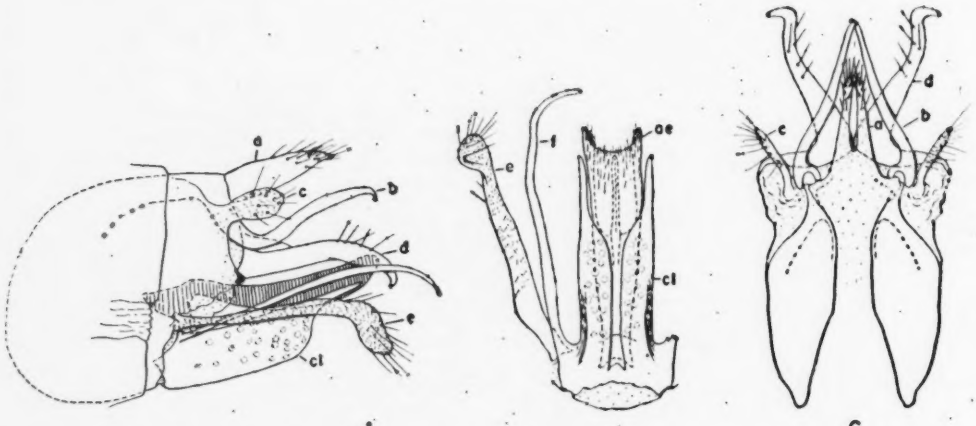

FIG. 1 FARULA MALKINI

FIG. 1.—Male genitalia of *Farula malkini* Ross (after Ross, 1950). A, Lateral view; B, ventral view; C, Dorsal view. a, dorsal lobe of ninth tergite; ae, aedeagus; b, ventral lobe of ninth tergite; c, cercus; cl, clasper; d, tenth tergite; e, lateral process of clasper.

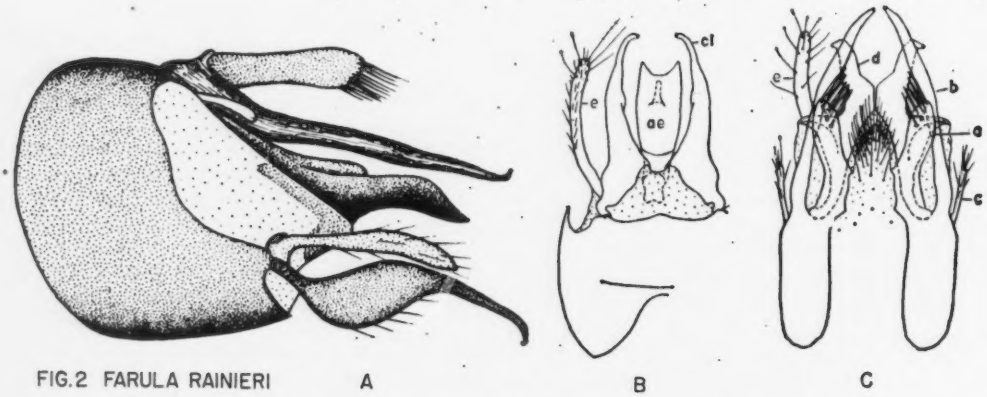

FIG. 2 FARULA RAINIERI

FIG. 2.—Male genitalia of *Farula rainieri* Milne. A, Lateral view (after Schmid, 1955); B, Ventral view, and C, Dorsal view (after Ross, 1950). Symbols as in figure 1.

Farula rainerii Milne

Farula rainieri Milne, 1936: 116, ♂; Ross, 1950: 419-21, fig. 12; Schmid, 1955: 71-72, figs. 45, 46.

This species is known only from the original type male. This holotype is in the Illinois Natural History Survey collection, and was taken at Mount Rainier, Washington, along White River, May 12, 1934, by W. E. Ricker. The male genitalia (see fig. 2) have been figured by Ross (1950), and the wings and genitalia by Schmid (1955).

Farula jewetti, new species

This is the third species described in the genus, and bears the closest resemblance to *F. rainieri* of those previously known. Distinguishing characters are found in the male genitalia, with the greatest differences occurring in the mesad-hooked apex of the claspers and the totally dissimilar ninth tergite.

Male.—Length 6 mm. Wings fuscous, pterostigma whitish; head, thorax, and femora blackish; antennae, palpi, and legs brownish, practically the same color as wings. Antennal scape slightly longer than head, second segment somewhat quadrate, distinctly set off from the other segments (fig. 3A). Lateral ocelli tuberculate. Maxillary palpi porrect, shorter than labial palpi, third segment only slightly longer than second, setation sparse. Head with pubescence scarce. Venation essentially as described for *F. rainieri* and *F. malkini*.

Genitalia as in figure 3. Process "a" (probably the dorsal lobe of the ninth tergite) somewhat digitiform from lateral aspect (fig. 3B), directed caudad, its distal margin bearing a very dense brush of closely appressed, stout, yellowish spines, the most ventrad of these almost as long as the structure itself; from dorsal aspect (fig. 3C) these long, stout spines have the appearance of a long, slender, distally acute and divergent process. Cercus, "c", short, slender, directed dorso-caudad. Process "b" (probably the ventral lobe of the ninth tergite) long, slender, acuminate, and convergent (fig. 3C); from lateral aspect (fig. 3B) it is slender and rod-like, and projects caudad slightly beyond any other part of the genitalia. Process "d" (probably the tenth tergite) from dorsal aspect (fig. 3C) directed caudad, separated on distal half, gradually tapering to a constricted, knobbed apex; the structure has an acute lateral angulation, as in *F. malkini* and *F. rainieri*. Claspers, "cl", from ventral aspect (fig. 3D) separated throughout, elongate, tapering distally

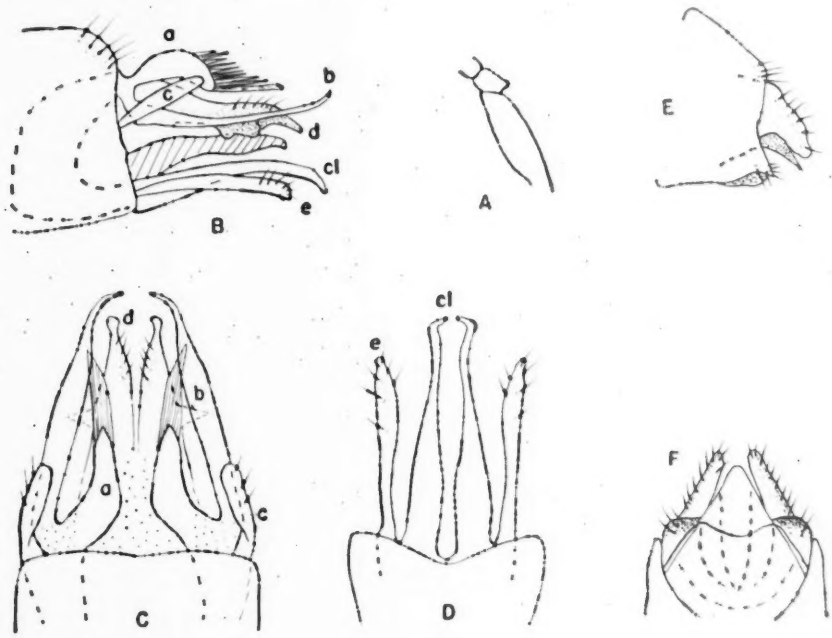

FIG. 3 FARULA JEWETTI

FIG. 3.—*Farula jewetti*, n. sp. A, Proximal segments of antenna; B, Male genitalia, lateral view; C, Male genitalia, dorsal view; D, Male genitalia, ventral view; E, Female terminalia, lateral view; F, Female terminalia, ventral view. Symbols as in figure 1.

to an acute apex which is hooked sharply mesad; from lateral aspect the apex is turned ventrad. Structure "e" (the fourth pair of appendages), best seen from ventral aspect (fig. 3D), long and slender; its homology unknown, apparently a lateral process of the clasper. Membranous tubular aedeagus barely discernable between the claspers.

Female.—Length 7 mm. Similar to the male in color and general structure. Genitalia as in figure 3. Ninth segment, from lateral aspect (fig. 3E), tubular, dorsal margin declivent, ventral margin straight; tenth tergite divided into two lateral lobes widely cleft, the rounded apex directed ventro-caudad and bearing a scattering of fine silky hairs; from ventral aspect (fig. 3F), lateral lobes of tenth tergite thin, spatulate; mesal lobe of subgenital plate is dorsad to the main structure, very thin and extending caudad nearly to apex of tenth tergite, wide at base and gradually tapering distally; spermatheca orbicular, occupying most of area, mesal aperture long, wide. The resemblance to *Neothremma* females is quite striking.

testaceous, appendages yellowish, wings uniformly ferrugineous. Details concerning venation, palpi, and antennae cannot be given owing to the poor condition of the two specimens at hand, which were collected in the sticky board traps used in a pear psylla survey.

Genitalia as in figure 4. From lateral aspect (fig. 4A), distal portion of process "a" digitate, basal portion fused to process "d"; from dorsal aspect (fig. 4C), slender, elongate, and approximated, with a scattering of short, fine setae. Process "b" attentuated, convergent, directed caudad for about same distance as process "d". Process "d" (probably the tenth tergite) from lateral aspect (fig. 4A) sinuate, its apex slender and acute, from dorsal aspect (fig. 4C) the apex gradually curved laterad; lateral margin about midway bearing a prominent, acute, lateral structure with distal margin darkened and heavily sclerotized. Cercus, "c", slender and elongate. Claspers, "cl", acuminate as seen from lateral aspect; from ventral aspect (fig. 4B) slender, elongate, connected at base by a narrow, sclerotized strap, their distal third narrowed to an

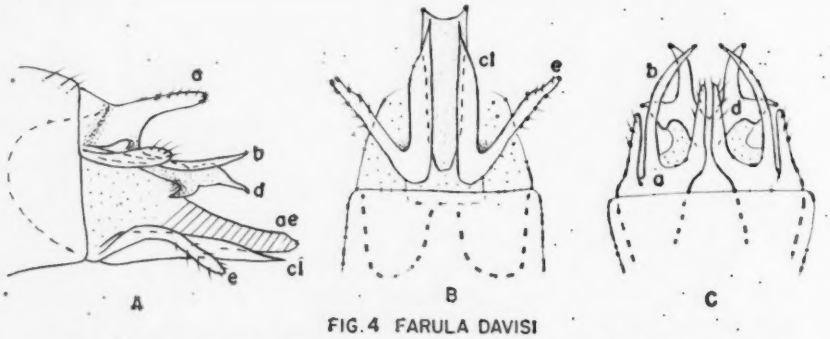

FIG. 4 FARULA DAVISI

FIG. 4.—Male genitalia of *Farula davisi*, n. sp. A, Lateral view; B, Ventral view; C, Dorsal view. Symbols as in figure 1.

Holotype male, allotype female, and one female paratype: Mount Hood, Oregon, tributary of Salmon River, July 9, 1955, S. G. Jewett, Jr. Another female paratype bears the same data except that it was collected June 24, 1956. Types will be deposited in the collection of the California Academy of Sciences, San Francisco, California.

It is with pleasure that I name this new *Farula* in honor of Mr. Stanley G. Jewett, Jr., Portland, Oregon, who collected the species and who has made so many contributions to our knowledge of the aquatic insects, especially in the Plecoptera.

Farula davisi, new species

This, the fourth known species in the genus, is easily separated from the others on the basis of the claspers, process "d" (the tenth tergite), and several other details in the male genitalia. Of the described species, it is closest to *F. malkini*.

Male.—Length 5 mm. Head and thorax acute, slender point, mesal margin straight. Process "e" elongate, of about the same thickness throughout, bearing a few short, fine, setae. Aedeagus, "ae", emarginate apically, gradually tapering toward base, trough-like.

Holotype male and one male paratype: Green Springs Mountain, 10 to 12 miles east of Ashland, Jackson County, Oregon, Fall 1950, John E. Davis. Types are in the collection of the writer. The pear psylla trap where these specimens were collected was placed in a tree near a small stream across a road from a marshy area.

I take pleasure in naming this new species in honor of Mr. John E. Davis, of the Oregon State Department of Agriculture, Salem, Oregon, who collected the specimens during a pear psylla survey in Oregon.

Thanks are due to Dr. H. H. Ross, of the Illinois Natural History Survey, for comparing *F. jewetti* and *F. davisi* with the holotype of *Farula rainieri*.

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NORTH AMERICAN LEPTOTHORAX OF THE NITENS-CARINATUS COMPLEX (HYMENOPTERA: FORMICIDAE)[1]

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ABSTRACT

Leptothorax nitens var. *Heathii* Wheeler is found to be indistinguishable from typical *L. nitens* Emery and is synonymized with it, while var. *mariposa* Wheeler is resurrected from synonymy and accorded full specific status. Other members of the complex are *L. andrei* Emery and *L. carinatus* Cole. Keys are given to the workers of these four species and to the females of three, that of *L. mariposa* being unknown.

Leptothorax nitens was first described by Emery (1895, p. 323) from a single worker collected at American Fork Canyon, near Salt Lake City, Utah. Wheeler (1903, p. 244) redescribed this small and highly distinctive ant and listed Pacific Grove, California, and Canyon City, Colorado, as additional localities. In the same publication (*op. cit.*, p. 245) Wheeler described *Heathii* as a new variety of *nitens*, from which it supposedly differed by a darker body color. The collection on which this brief description was based consisted of approximately an entire colony which had been taken at Pacific Grove, California. Wheeler (1917, p. 507) further described as new the variety *mariposa* from several workers taken from nests beneath stones in dry portions of Tenaya Canyon, Yosemite National Park, California. The variety *mariposa* was said to differ from the typical *nitens* in the opaque and densely and coarsely punctate thorax, petiole, and postpetiole.

Creighton (1950, p. 265) synonymized *mariposa* under *nitens* because he believed the coarse sculpture of the former to be within the normal limits of variation in *nitens*. He also elevated *heathi* to subspecific rank on the basis of a notably shorter antennal scape in comparison with head length, and a darker body color.

From collections made by the writer in various western states during these last 6 years I was able to study intensively long series of *nitens*, as well as its possible major variants, taken from a total of 79 nest collections made largely in California, Nevada, Arizona, Oregon, and Utah. A random series of 25 workers from each collection was studied carefully, whereas an additional series of 25 workers was examined for pilosity, sculpture, and comparisons of antennal scape and head lengths. Furthermore, numerous males and females were studied, chiefly on a comparative basis, and a description of each of the sexes was formulated.

My studies have shown that the worker of *nitens* is a highly variable species, both intranidally and internidally, in at least four chief respects, namely, body color, scape length compared with head length, surface sculpture, and length of epinotal armature. The species varies in color from a pale, concolorous yellow through various increasing degrees of infuscation to a medium tan. Moreover, there is a considerable degree of variability in scape length with regard to head length, all the way from a condition in which the scape in repose fails by more than its own maximum diameter to reach the occipital border, to a contrasting type in which the scape apex even slightly surpasses the occipital border. The body surface in a great many specimens is virtually free of sculpture and highly shining, a condition which is particularly applicable to the cephalic dorsum. In others the body is largely finely punctate, with the head bearing a median longitudinal band which is shining, puncture-free, and of variable width. In still other workers the entire body is punctate, and varies from slightly shining to subopaque. However, only punctures,

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regardless of their degree of prominence, are present. There are no rugulae. Epinotal armature varies from denticles to definite spines with broad bases and sharp tips. When spines are present, as they are in a great many workers, they appear always to be directed upward and backward.

An invariable feature of the worker of *nitens* is the cuneate petiolar node in profile view. Although the acuteness of the apex undergoes some slight modification, the node is always distinctly cuneate. On the basis of this characteristic, *nitens* can be distinguished from all other known species in the complex with the exception of *mariposa*, which has a similar shape of the petiolar node.

As a result of extended investigations, I was able to reach certain conclusions which, to some degree, are in conflict with those of Creighton (1950). First of all, it has become evident that *nitens* has undergone a great deal of variation in such important characteristics as body color and sculpture, as well as in scape length related to head length. The characters of color and scape length will not serve effectively to separate *heathi* from *nitens*, and inasmuch as I have been unable to find stable separatory characteristics of any nature I propose that *heathi* Wheeler be made a synonym of *nitens* Emery.

It should be noted that the type series of *heathi* was ostensibly collected at Pacific Grove, California, from which locality Wheeler (1903, p. 245) also recorded *nitens*. Creighton (1950) regarded *heathi* as a lowland race of *nitens*. Pacific Grove lies virtually at sea level. It is, therefore, scarcely the sort of habitat where one would expect the genus to be represented. Although we spent a full day intensively collecting in that very dry and sandy area, not a single specimen of *Leptothorax* was found. I suspect, then, that both the types of *heathi* and the series of *nitens* mentioned by Wheeler came from the mountains west of Pacific Grove rather than from the adjacent coastal area.

The synonymy of *nitens* and brief descriptions of the sexual castes follow.

Leptothorax nitens Emery

L. nitens Emery, 1895, Zool. Jahrb. Syst. 8: 323, pl. 8, fig. 16, worker; Wheeler, 1903, Proc. Acad. Nat. Sci Phila. 55: 244, pl. 12, fig. 15, worker.
L. nitens var. *Heathii* Wheeler, 1903, Proc. Acad. Nat. Sci. Phila. 55: 245, worker. (NEW SYNONYMY).
L. nitens subsp. *heathi* Wheeler, Creighton, 1950, Bull. Mus. Comp. Zool. 104: 265, worker. (NEW SYNONYMY).
L. nitens subsp. *occidentalis* Wheeler, 1903, Proc. Acad. Nat. Sci. Phila. 55: 245, worker.

Male.—Head densely punctate and subopaque except for a narrow longitudinal strip, between the median ocellus and the clypeus, which is finely and faintly punctate and rather shining; hairs sparse, slender, pointed, erect and suberect, yellow, of variable length, mostly limited to ocellar area, mandibles, and clypeus. Thorax, except scutum, strongly shining, very faintly punctulate and longitudinally striate; scutum distinctly striato-punctulate and shining to subopaque; epinotal declivity finely and faintly punctate. Mayrian furrows moderately developed. Thoracic dorsum with sparse, slender, pointed, mostly suberect and subappressed, moderately long hairs which are longest on scutellum. Petiolar and postpetiolar nodes with very sparse, suberect hairs. Gaster with sparse, scattered, moderately long, slender, pointed, appressed, subappressed, and suberect hairs. Pubescence absent from entire body.

Female (alate).—Epinotal spines prominent, rather long, very broad at base, pointed apically, directed posteriorly. Petiole and postpetiole as in worker. Cephalic dorsum with very sparse, rather long, blunt, slender, erect, yellow hairs. Gular area with abundant, short, slender, pointed, suberect hairs. Thoracic dorsum with numerous erect, mostly short (but variable in length), slender, blunt, yellow hairs. Hairs on petiolar and postpetiolar nodes long, slender, pointed, rather numerous. Lateral surfaces of epinotum densely punctate; infraspinal facet transversely striato-punctate. Head and thorax rather uniformly and longitudinally rugulose, faintly and finely punctulate, and shining. Gastric hairs moderately abundant, slender, scattered, of unequal length, erect and suberect dorsally, suberect laterally. Pubescence everywhere very dilute. Body color a rather deep tan, gaster strongly infuscated.

Leptothorax mariposa Wheeler, new status

L. nitens var. *mariposa* Wheeler, 1917, Proc. Amer. Acad. Arts and Sci. 52: 507, worker.

The status of *mariposa* Wheeler is quite another matter than that of *heathi*. At Tenaya Canyon, Yosemite National Park, as well as at Glacier Point in the same general area, I found several colonies which answer to a broad general description of *nitens* but which, during a critical examination, proved to be quite different. The colonies were under stones on dry coniferous slopes at elevations above 7,000 feet. From them I was able to collect only workers which are significantly larger in stature than those of *nitens* and which possess heads which are far more quadrate.[2] Moreover, the epinotal spines average notably longer than those of *nitens*, and the thorax as well as the petiolar and postpetiolar nodes are not only very coarsely punctate but are also prominently longitudinally rugulose. At the same situation were nests of *nitens*. There was not the slightest indication of an intergradation of these separatory characteristics. This popula-

[2]The average cephalic index of *mariposa* is 96; that of *nitens* is 79. The average total thoracic length of *mariposa* is 0.95 mm.; that of *nitens* is 0.71 mm.

tion which differs from that of *nitens* is, in my opinion, representative of Wheeler's *mariposa*. It does not fall within even the very broad variational limits of *nitens*.

I propose, therefore, that the name *mariposa* Wheeler be resurrected and that the population concerned be elevated to full specific status. A brief description of the worker follows.

Worker.—Head only slightly longer than broad, with an average cephalic index[3] of 96; densely punctate and subopaque; scape length variable. Thorax and petiolar and postpetiolar nodes longitudinally rugulose, the rugae not obscured by the dense, coarse punctures. Average total thoracic length[3] 0.95 mm. Epinotal spines rather long, equalling about one-half the distance between their bases. Body color a medium to dark reddish brown, gaster darker.

Leptothorax andrei Emery

L. andrei Emery, 1895, Zool. Jahrb. Syst. 8: 322, pl. 8, fig. 15, worker; Wheeler, 1903, Proc. Acad. Nat. Sci. Phila. 55: 256, pl. 12, fig. 22, worker.

Another species in the complex is *andrei* Emery, which has California as its type locality. It is indeed unfortunate that there are no types in this country, but it is my belief that the population can be clearly recognized on the basis of the descriptions by Emery and by Wheeler.

My collections of *andrei* come from Yosemite National Park (4,000 feet), California; Lee Canyon (7,200 feet), Charleston Mountains, Nevada; Kaibab Forest (7,000 feet), Arizona; and Sandia Mountains, Bernalillo County, New Mexico. The species appears, therefore, to have a rather wide range in the western states. All nests were either beneath stones or between relatively loose layers of large stones in comparatively dry coniferous forests.

The worker of *andrei* is, I believe, a very distinctive ant, and one should have no difficulty in distinguishing it from other members of the complex. Descriptions of the sexual castes follow.

Male.—Head finely and sparsely punctate, shining; vertex with a few widely-spaced, fine, blunt, erect, golden hairs. Thorax faintly shagreened, strongly shining; dorsum (except epinotum) and petiolar and postpetiolar nodes with very sparse, moderately long, slender, blunt, suberect hairs. Petiolar and postpetiolar nodes smooth, strongly shining. Gaster with sparse, slender, pointed, erect and suberect hairs.

Female (alate).—Head moderately shining, longitudinally punctate-rugulose; dorsum with rather coarse and numerous, scattered, widely-spaced, short, blunt, yellow, fully erect hairs which are subequal in length; gular region with several slender, moderately long, pointed hairs. Thorax with dorsum very smooth, nearly free of any sculpture, highly shining; lateral surfaces shining, very faintly longitudinally striolate except for those of epinotum which are rather strongly longitudinally punctato-rugulose and dull; epinotal spines prominent, rather long, very broad at base, dully pointed at apex, directed posteriorly; infraspinal facet shining, faintly punctate; hairs virtually limited to dorsum and similar to those of cephalic dorsum but more sparse. Petiolar and postpetiolar nodes like those of worker; hairs limited to nodes, somewhat longer than those on head and thorax.

[3]Based on a total of 100 workers from four collections.

Leptothorax carinatus Cole

L. carinatus Cole, 1957, Jour. Tenn. Acad. Sci. 32: 213.

This is the most recently described member of the complex. Its type locality is Limpia Canyon (5,400 feet), Davis Mountains, Texas. During the summer of 1957 the writer found three additional nests at the type locality. Although a queen was taken from one of these nests, no winged castes were found. The male apparently is unknown.

That the range of *carinatus* is not limited to the immediate region of its type locality has been proved by a collection of workers which I made from a nest beneath a stone on a dry, forested slope at an elevation of 5,400 feet in the Chiricahua Mountains, Arizona. The specimens compary very favorably with the types.

Although *carinatus* certainly appears to be a very distinctive species, I am now inclined to minimize the significance of the pronotal carina as a usable separatory character. Studies of the entire complex have revealed that this feature can show a considerable amount of variation. Undoubtedly the most definitive characteristic of the worker of *carinatus* is the very broad postpetiolar node, which contrasts sharply with the postpetiolar nodal breadth in all other species in the complex. Also important as a separatory characteristic is the shape, in profile, of the petiolar node of *carinatus*. This does not attain the apical breadth and shape of that of *andrei*, but it is not cuneate like that of both *nitens* and *mariposa*. There are relatively minor pilosity differences also.

All members of the complex may at times use nesting sites other than those beneath or between stones, but it is worth noting that I have never found nests under bark of trees or logs, within decaying wood, or in the open soil. Colony strength appears to vary considerably, and the number of workers which I have aspirated from nests shows the following range for each of the species concerned: *nitens*, 69 to 276; *mariposa*, 58 to 97; *andrei*, 32 to 109; and *carinatus*, 29 to 182.

Males and females were found in the nests of *nitens* on June 22 (southern Arizona), July 19

to 23 (southern Nevada), July 22 to 29 (northern California), and August 7 to 12 (southern Oregon); those of *andrei* on July 18 (northern Arizona).

The following keys to workers and females should aid in distinguishing the species from one another.

A KEY TO THE WORKERS

1. Petiolar node, when viewed in profile, strongly cuneate, the apex rather sharp; gular region with numerous, short, scattered, uneven, erect and suberect hairs 2
   Petiolar node, when viewed in profile, not strongly cuneate, the apex very blunt; gular region with a few (one to three) long, erect hairs 3
2. Thorax, petiole, and postpetiole with coarse punctures and pronounced longitudinal rugulae; average cephalic index 96; average total thoracic length 0.95 mm ..... **mariposa** Wheeler
   Thorax, petiole, and postpetiole without pronounced longitudinal rugulae, the surface punctate only; average cephalic index 79; average total thoracic length 0.71 mm ..... **nitens** Emery
3. Node of petiole, when viewed in profile, nearly as broad apically as basally, the apical border strongly and evenly rounded; width of postpetiolar node, when viewed from above, distinctly less than twice that of petiolar node ..... **andrei** Emery
   Node of petiole, when viewed in profile, considerably less broad apically than basally, the apical border rather blunt; width of postpetiolar node, when viewed from above, at least twice that of the petiolar node ..... **carinatus** Cole

A KEY TO THE FEMALES[*]

1. Gular region with short, suberect or subappressed hairs; thoracic dorsum with moderately abundant to abundant short hairs; infraspinal facet of epinotum transversely and finely to coarsely punctato-striolate, the surface subopaque to opaque 2
   Gular region with a few long, erect hairs; thoracic dorsum with sparse, moderately long hairs; infraspinal facet of epinotum faintly punctulate, the surface shining ..... **andrei** Emery
2. Pilosity fine; hairs on thoracic dorsum pointed, uneven in length; epinotum finely punctato-striolate, the surface subopaque ..... **nitens** Emery
   Pilosity coarse; hairs on thoracic dorsum blunt, rather even in length; infraspinal facet of epinotum coarsely punctato-striolate, the surface opaque ..... **carinatus** Cole

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[*]The female of *mariposa* apparently is unknown.

A COMPARATIVE STUDY OF THE DORSAL VESSELS OF BEES[1]

ALVARO WILLE

ABSTRACT

Two main types of dorsal vessels were found in the 101 species dissected, representing 61 genera and including most of the major groups of bees. In one type the dorsal vessel is straight and runs dorsal to the gut; in the other type it makes an arch between the dorsal longitudinal muscles of the thorax, sometimes with a series of loops just behind the ascending portion. Intermediate types occur. Within any family or tribe in which both main types occur, that with the straight thoracic portion is always found in the primitive forms; and vessels with a series of loops are found only in the most specialized bees. An evolutionary trend is evident toward reduction of the posterior section of the dorsal vessel and its ostia. In the Meliponini, or stingless bees, a trend is found toward enlargement of the last two chambers, culminating in the Euglossini where the enlarged chambers probably serve as a powerful pumping mechanism. Some characteristics of the dorsal vessel are of possible taxonomic importance. The number and location of the metasomal ostia are significant for separation of some families, while other characteristics are typical of groups of genera and of tribes or subfamilies.

Our present knowledge of the internal anatomy of bees is mainly based on that of the honey bee. This is rather unfortunate because the domestic bee is in many respects different in its internal anatomy from the great majority of bees. For this reason much work has to be done on the anatomy of other bees in order to gain a better understanding of their morphology. Comparative studies of this nature may prove to have immediate taxonomic value, and as they are made for more organ systems, should contribute to our understanding of phylogeny. During the course of a study on the relationships of the genera and subgenera of the stingless bees, in which the author is at present engaged, it was soon evident that the two main groups of the stingless bees, namely *Melipona* and *Trigona*, could be differentiated by their dorsal vessels. This led to a study of the dorsal vessels among other bees.

Work of this nature is commonly limited by the amount of alcoholic material available; fortunately bees representing most of the main groups were

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available. A total of 101 species distributed in 61 genera was examined. They are as follows. Family COLLETIDAE: *Belopria*, undescribed genus near *Lonchopria*, *Hylaeus* (2 species), *Colletes* (3 species), *Ptiloglossa*. Family HALICTIDAE: *Augochloropsis* (4 species), *Augochlora*, *Augochlorella* (2 species), *Agapostemon* (3 species), *Halictus* (3 species), *Megalopta*, *Pseudaugochlora*, *Paroxystoglossa*, *Sphecodes*, *Lasioglossum* (2 species), *Dufourea*, *Nomia* (2 species). Family ANDRENIDAE: *Andrena* (2 species), *Perdita*, *Psaenythia*, *Pseudopanurgus*, *Calliopsis*, *Oxaea*. Family MEGACHILIDAE: *Heriades* (2 species), *Megachile* (2 species), *Coelioxys*, *Osmia*, *Anthidium*, *Heteranthidium*, *Paranthidium*, *Dianthidium*. Family APIDAE: *Paratetrapedia* (2 species), *Exomalopsis* (2 species), *Ancyloscelis*, *Monoeca*, *Nomada*, *Triepeolus*, *Neopasites*, *Ptilothrix*, *Diadasia* (2 species), *Melitoma*, *Xenoglossa*, *Xenoglossodes*, *Florilegus*, *Thygater*, *Svastra*, *Melissodes* (2 species), *Peponapis*, *Anthophora* (3 species), *Centris* (2 species), *Epicharis*, *Xylocopa* (3 species), *Ceratina*, *Trigona* (10 species), *Melipona* (4 species), *Lestrimelitta*, *Bombus* (3 species), *Apis*, *Euglossa*, *Euplusia*, *Eulaema* (2 species).

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METHODS

The specimens were preserved in Kahle's (Dietrich's) fixative. Dissections were done under water, and usually more than one specimen was dissected for every species studied. All the drawings were made diagramatically. For descriptive purposes a special terminology was used for the dorsal vessel; this is indicated in figure 1. When a series of loopings of the vessel was present, the number of them was determined by counting the loops made only at one side. In diagramming the vessels, for convenience all loops are shown as though they were in a sagittal plane. This is not entirely true, however, of those in the first metasomal segment and petiolar regions. These loops are usually more transverse than vertical. In determining the location of a metasomal ostium[2] in relation to a segment (anterior, middle, or posterior) the limits of the segment were determined internally, in which case the posterior limit is marked by the conjuntive and anterior border of the following segment. Observations were made with the high power of a dissecting microscope. No sections were cut; therefore, some of the ostia recorded may not have been functional. The metasomal ostia, as they appear in the dissections, are indicated by constrictions. Laterally, each constriction is somewhat overlapped by the wider anterior section (figure 14). The mesosomal ostia, and usually the first metasomal one, are not indicated by obvious constrictions in the dissections. They usually appear as more transverse divisions, but in some bees they are almost identical to those of the metasoma except for being smaller. For the classification of bees, that of Michener (1944) has been followed.

GENERAL ACCOUNT

Good descriptions of the circulatory organs in the honey bee have been given by Freudenstein (1928) and Snodgrass (1956). A brief description of the dorsal vessel of *Megachile bombycina Radoszkowsky* was given by Popovici-Baznosanu (1910).

In general, the dorsal vessel of bees extends from the fifth or sixth metasomal segment into the head. In the metasoma the vessel is very close to the dorsal wall. In the mesosoma it is straight in some bees, just dorsal to the gut; in others it makes an arch between the dorsal longitudinal muscles of the thorax, with ascending, horizontal, and descending portions (see fig. 1). In the thorax the vessel is never very close to the dorsal wall (closest in *Xylocopa*, fig. 17) although in the larva of the honey bee the vessel is located just beneath the cuticle in both the thorax and the abdomen. In the head the vessel opens just behind the brain, between the corpora allata. The dorsal vessel is perforated by the ostia; in the metasomal region there are five or six ostia, and in some primitive bees seven in the males. In the thoracic region there are two ostia: the propodeal, which is in the propodeal segment or first true abdominal segment, and the thoracic, which probably corresponds to the metathoracic segment. The thoracic and propodeal ostia are usually less evident than those of the metasoma and are probably non-functional in some bees; however, they are quite evident in the family Megachilidae and some of the primitive bees of the family Apidae. In the most specialized bees of the family Apidae the thoracic and propodeal ostia are not always evident in every specimen.

[2]The term "ostium" is used throughout to refer to the location of two ostia, one on either side of the vessel.

although indications of them have been seen in most specimens, including the thoracic ostium in the honey bee, which until now has escaped the attention of the honey-bee anatomists.

According to Nelson (1924) the dorsal vessel of the honey-bee larva extends from the ninth abdominal segment into the head; in the thorax there are two ostia corresponding to the mesothorax and metathorax and nine ostia in the abdomen which correspond to the nine abdominal segments. Therefore, judging by the anatomy of the honey-bee larva, the adult has lost the mesothoracic ostium and the last two or three abdominal ostia.

Table 1.—Occurrence of types of dorsal vessels among bees[a]

Thoracic portion straight	Thoracic portion making an arch between longitudinal thoracic muscles	
	a) without a series of loops	b) with loops in a series in petiolar region
Paracolletini	Colletini	Exomalopsini: *Monoeca*
Hylaeinae	Diphaglossinae	Eucerini: *Xenoglossodes* *Thygater* *Melissodes* *Peponapis* *Svastra*
Halictinae	Nomiinae	Anthophorini
Dufoureinae	Megachilinae: *Megachile* *Coelioxys* *Anthidium* *Heteranthidium* *Paranthidium*	Centrini: *Epicharis*
Andreninae	Emphorini	Xylocopini
Panurginae	Eucerini: *Xenoglossa* *Florilegus*	Apini
Megachilinae: *Heriades* *Dianthidium*	Centrini: *Centris*	Euglossini: *Euglossa* *Euplusia*
Exomalopsini: *Exomalopsis* *Paratetrapidia* *Ancyloscelis*	Meliponini: *Melipona*	
Nomadini	Bombini	
Epeolini	Euglossini: *Eulaema*	
Neopasitini		
Ceratinini		
Meliponini: *Trigona*		

[a]When only a subfamily or tribe name is given, bees examined in that particular group were found to be of the same type.

COURSE OF THE DORSAL VESSELS

There are two main types of dorsal vessels in bees: 1) those which have the thoracic portion straight, running along and dorsal to the gut; and 2) those which have the thoracic portion making an arch between the dorsal longitudinal muscles of the thorax. The latter group can be further subdivided into two subgroups: a) without a series of loops, and b) with a series of loops just behind the ascending portion and including the region of the propodeal ostium. The occurrence of these types among the various groups of bees is summarized in Table 1.

Intermediate types between those listed in Table 1 exist. Thus in *Augochloropsis*, *Augochlora*, and *Andrena* the thoracic portion is straight but somewhat elevated between the longitudinal muscles of the thorax where it is held attached by tracheae. but is still visible ventrally. A better intermediate type is that found in the genus *Nomia*, in which the arch is rather gentle (fig. 7).

There is also a series of bees which are intermediate between subtypes 2a and 2b. These intermediates are summarized in Table 2.

The series of loops in the honey bee has been interpreted by Zander (1951) as serving as a spring mechanism. When the longitudinal muscles are contracted, according to Zander, the phragma is pulled forward and, because the ascending portion of the vessel lies along the midline of the phragma, that part of the heart is also pushed forward. The series of loops then would allow for this movement. Although this simple explanation seems very logical, the present

Table 2.—Number of loops in petiolar region

Number of Loops	Bees
1	*Centris*, *Bombus ephippiatus*, *Eulaema*
3	*Epicharis*
4	*Melissodes coloradensis*, *Svastra*, *Xylocopa*, *Peponapis*, *Euplusia*
5 or 6	*Monoeca*, *Melissodes agilis*, *Anthophora*, *Euglossa*, *Xenoglossodes*, *Thygater*
9 or 10	*Apis*

study does not support this interpretation. To begin with, there are many bees such as in *Oxaea* (fig. 8) *Anthidium* and *Paranthidium* with the dorsal vessel similar to that of the honey bee but without either the series of loops or the thoracic loop. Therefore, the series of loops in a dorsal vessel which makes an arch between the dorsal longitudinal muscles of the thorax is not essential in allowing phragmal movements. It appears that the function of the loops is other than merely to allow for the forward movement of the phragma when the logitudinal muscles are contracted. This is still more evident in the case of the wasp *Bembix*, in which the thoracic portion of the dorsal vessel is straight, yet a series of loops is present in the petiole and posterior section of the thorax.

EVOLUTIONARY TRENDS

It was assumed that the dorsal vessel with the thoracic portion straight (type 1) was a generalized condition compared with the one with an arch in

the thorax (type 2). It was also assumed that within the bees having type 2 vessels, a series of loops was still more specialized. Finally, a vessel with the last two chambers much enlarged was considered the most specialized. The comparative study of the dorsal vessel seems to support these views. In any family or tribe in which both types are found, the type 1 is always found among the more primitive forms (see table 1). Those with a series of loops are found only in the Family Apidae and only among the most specialized tribes of that family, except for *Monoeca* in the Exomalopsini.

A trend toward an enlargement of the last two chambers is found in the Meliponini or stingless bees (fig. 19), and such enlargement culminates in the Euglossini (figs. 22, 23, 24), in which the enlarged chambers are very muscular and probably serve as a powerful pumping mechanism.

The characters discussed above, while of apparent phylogenetic interest within the various families are not useful in the separation of these families. The number of ostia, and their positions, however, seem to offer family characters among the bees.

A definitie trend toward the reduction of the posterior section of the dorsal vessel and its ostia is evident among the bees. In the most primitive family, Colletidae, the vessel starts at the extreme posterior end of the abdomen in both sexes (at least in the specimens examined) and there is an ostium for each of the metasomal segments. In view of the fact that the males have one more well developed metasomal segment than the females, it is not surprising that the females have six metasomal ostia and the males have seven. This is clearly seen in the genus *Colletes*; however, in those males which have the seventh segment smaller and not well developed, the corresponding ostium of that segment is sometimes difficult to see. In the families Halictidae, Andrenidae and Megachilidae the seventh metasomal ostium of the males is missing, as is the chamber which would correspond to that segment. A definite loss of the most posterior section of the vessel, including the sixth ostium, is found in the bees belonging to the family Apidae. Both sexes of all the bees of this family have only five metasomal ostia, with the vessel ending in the fifth metasomal segment. In this connection it should be mentioned that one specimen of *Paratetrapedia* (*Trigonopedia*) *oligotricha* (among the most primitive of the family Apidae) was found with indications of the sixth metasomal ostium, but drawn forward into the fifth segment; other specimens of the same species did not show that rudiment, indicating this is not a constant condition.

Differences in the location of the ostia in relation to the metasomal segments are found in some groups. Table 3 summarizes the numbers and locations of metasomal ostia in various bees.

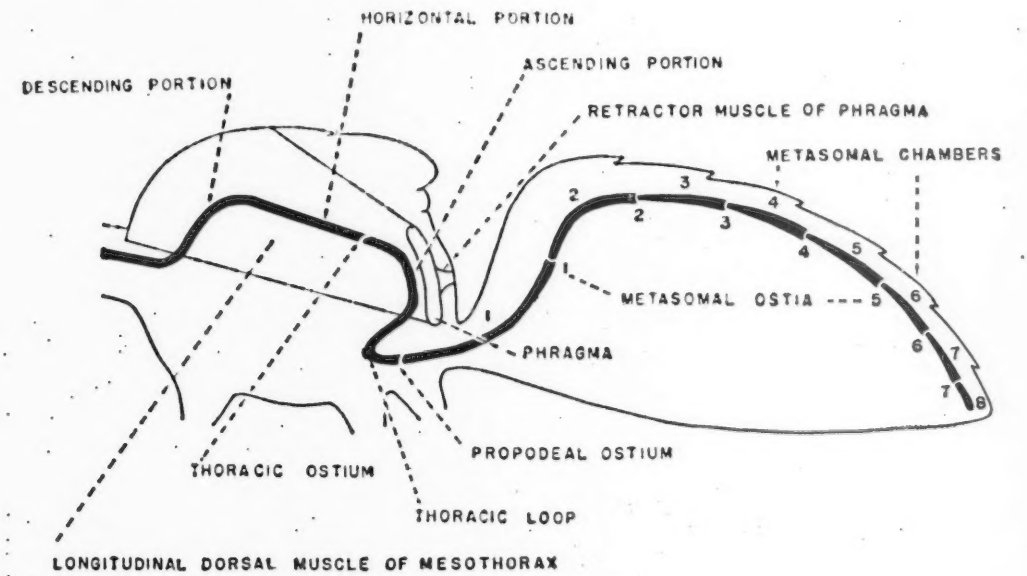

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FIG. 1.—Lateral view of a hypothetical bee showing the terminology used for the dorsal vessel.

DESCRIPTIVE ACCOUNTS

FAMILY COLLETIDAE

The two main types of dorsal vessels are represented (figs. 2, 3). There are six metasomal ostia in females and seven in males, although the seventh ostia in the males of *Belopria* and *Hylaeus* are not too clear because of the smaller size of that segment. The thoracic and propodeal ostia were evident in all specimens examined.

Subfamily Hylaeinae

In *Hylaeus* (*Prosopis*) *modestus* Say (male and female) and *Hylaeus* (*Hylaeus*) *cressoni* (Cockerell) (male and female) the thoracic portion of the dorsal vessel is straight (fig. 2).. The thoracic ostium is located about the middle of the thorax. The first metasomal ostium is near the middle of the first segment; the remaining metasomal ostia are located anterior to the middle of each segment.

Table 3.—Number and location of the metasomal ostia

Bees	Number of Metasomal Ostia	Location of Metasomal Ostia
Colletidae	6 in females; 7 in males	At least in posterior segments, anterior to middle of each segment
Andrenidae Halictidae	6 in both sexes	anterior to middle of each segment
Megachilidae		posterior to middle of each segment
Apidae: Anthophorinae Xylocopini	5 in both sexes	anterior to middle of each segment
Apidae: Ceratinini Apinae		at or behind middle of each segment

Subfamily Colletinae

Tribe Paracolletini

Belopria zonata Moure (male and female) was found to be essentially the same as *Hylaeus*. The same was true with another species belonging to an undescribed genus near *Lonchopria* (female).

Tribe Colletini

In *Colletes punctipennis* Cresson (female) the thoracic portion of the vessel makes an arch between the longitudinal muscles of the thorax. Just before entering the space between the muscles, the vessel makes a small loop in the posterior portion of the thorax, called here thoracic loop (fig. 1). The entrance between the longitudinal muscles is close to the anterior ventral border of the phragma; the ascending portion of the vessel is located along the midline of the phragma. The descending portion slopes gently and is not well differentiated from the horizontal portion. The thoracic ostium is located beneath the metanotum, the propodeal one just before the thoracic loop. The metasomal ostia are located as in *Hylaeus*. The possession of the seventh ostium in the male is well shown in this genus, at least in the males of two unknown Mexican species of *Colletes*, one from Carmen, Hidalgo, and the other from Pachuca (fig. 4).

These Mexican species are essentially the same as in *C. punctipennis*, except that the descending portion of the vessel is somewhat better differentiated (fig. 3).

Subfamily Diphoglossinae

Tribe Caupolicanini

Ptiloglossa mexicana (Cresson) (female) has a dorsal vessel similar to that of *Colletes*, but the following differences exist: descending portion well differentiated from the horizontal portion. Propodeal ostium located in the petiole or in the anterior portion of first metasomal segment. Second and third metasomal ostia lying near middles of their respective segments. Such an arrangement seems to indicate that the first four abdominal ostia have been shifted somewhat backwards (fig. 5).

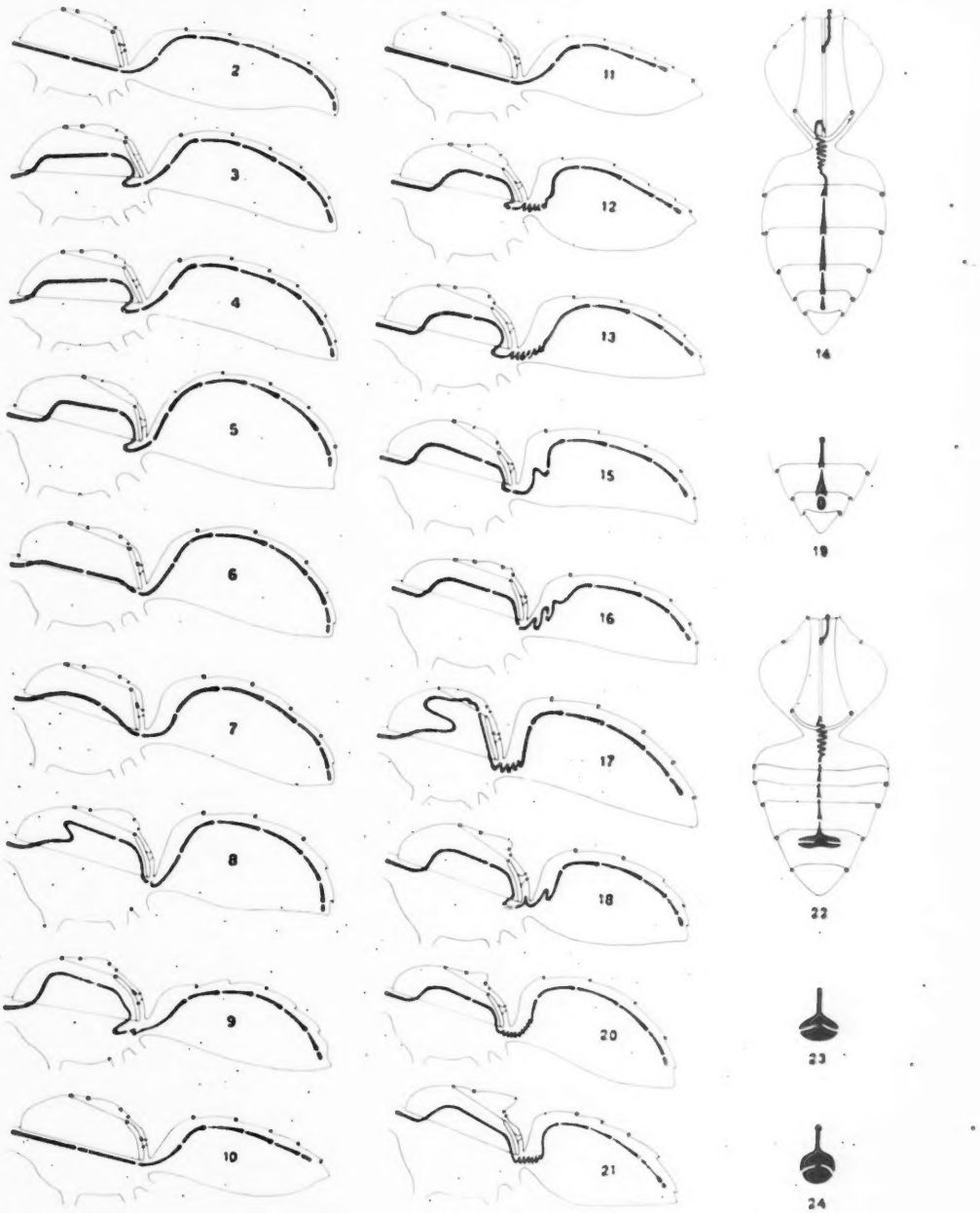
Family Halictidae

Except for the genus *Nomia*, all the species examined have the thoracic portion of the dorsal vessel straight. All the females and males dissected have six metasomal ostia. The ostia are located as in *Hylaeus*.

Subfamily Halictinae

The following species were dissected: *Augochloropsis brachycephala* Moure (male and female), *Augochloropsis diversipennis* (Lepeletier) (female), *Augochloropsis sparsilis* (Vachal) (female), *Augochloropsis cuprea* (Smith) (female), *Augochlora pura* (Say) (female), *Augochlorella aurata* (Smith) (female), *Augochlorella striata* (Provancher) (female), *Agapostemon radiatus* (Say) (female), *Agapostemon* sp. (female, Carmen, Hildalgo, Mexico), *Pseudagapostemon divaricatus* (Vachal) (female), *Megalopta genalis* Meade-Waldo (female), *Pseudaugochlora nigromarginata* (Spinola) (male), *Paroxystoglossa jocasta* (Schrottky) (male and female), *Halictus* (*Seladonia*) *hesperus* Smith (worker), *Halictus* (*Halictus*) *ligatus* Say (female), *Halictus* (*Halictus*) *parallelus* (Say) (female), *Lasioglossum* (*Chloralictus*) *stultum* (Cresson) (worker), *Sphecodes* sp. (female).

The thoracic and propodeal ostia are evident



All figures are lateral views of the dorsal vessel except as follows: figures 14 and 22 represent ventral views, and figures 19, 23, and 24 show the last two chambers of the dorsal vessel from the ventral view.

FIG. 2.—*Hylaeus modestus* Say, female; FIGS. 3 and 4.—*Colletes* sp., female (3) and male (4); FIG. 5.—*Ptiloglossa mexicana* Cresson, female; FIG. 6.—*Augochlora pura* (Say), female; FIG. 7.—*Nomia heteropoda* Say, female; FIG. 8.—*Oxaea flavescens* Klug, female; FIG. 9.—*Megachile brevis* Say, female; FIG. 10 and 11.—*Paratetrapedia oligotricha* (Moure), female (10) and male (11); FIG. 12.—*Monoeca mexicana* (Radoszkowsky), female; FIGS. 13 and 14.—*Xenoglossodes spissa* (Cresson), female; FIG. 15.—*Centris vittata* Lepeletier, female; FIG. 16.—*Epicharis elegans* Smith, female; FIG. 17.—*Xylocopa brasilianorum* (Linnaeus), female; FIGS. 18 and 19, *Melipona marginata* Lepeletier, worker; FIG. 20, *Apis mellifera* Linnaeus, worker; FIGS. 21 and 22, *Euglossa cupreiventris* Cheesman, female; FIG. 23, *Euplusia coerulescens* (Lepeletier), female; FIG. 24, *Eulaema dimidiata* (Fabricius), female.

in most species. In *Halictus parallelus*, *Megalopta genalis* and *Pseudaugochlora nigromarginata* the thoracic ostium is not evident. For lack of material only one specimen was dissected for each of the above three species. It should be pointed out that sometimes one specimen would not show one of the ostia, but in another specimen of the same species the ostium may be evident.

Of all the species dissected of the subfamily Halictinae, only those belonging to the genera *Augochloropsis* and *Augochlora* are found with a minor difference: the thoracic portion of the dorsal vessel is slightly elevated between the lower edges of the longitudinal muscles of flight, but is still visible from the ventral side (fig. 6).

Subfamily Dufoureinae

Dufourea (*Halicotoides*) *marginata* (Cresson) (male and female) is essentially the same as in the subfamily Halictinae.

Subfamily Nominae

In both *Nomia* (*Dieunomia*) *heteropoda* (Say) (male and female) and *Nomia* (*Acunomia*) *foxii* Dalla Torre (female) the thoracic portion of the dorsal vessel forms a rather slight arch between the longitudinal muscles of flight. This arch is not differentiated into ascending, horizontal and descending portions. The thoracic loop is lacking. All the ostia are evident and located as in *Colletes* (fig. 7). This type of vessel actually represents an intermediate between the two main types found in bees.

Family Andrenidae

As in the family Halictidae, all the species examined have the thoracic portion of the dorsal vessel straight, except the genus *Oxaea*, and all the females and males dissected have six metasomal ostia. The ostia are also located as in *Hylaeus*.

Subfamily Andreninae

Andrena argemonis Cockerell (male and female) and *Andrena bipunctata* Cresson (female) have a dorsal vessel essentially the same as that of *Augochloropsis* and *Augochlora*, that is to say, with the thoracic portion of the vessel essentially straight but slightly elevated between the longitudinal muscles of the thorax, although still visible from beneath.

Subfamily Panurginae

The following species were dissected: *Perdita lacteipennis* Swenk and Cockerell (male and female), *Psaenythia* (*Protandrena*) *mexicanorum cockerelli* (Dunning) (female), *Calliopsis* (*Calliopsis*) *andreniformis* Smith (female) and *Pseudopanurgus* (*Heterosaurus*) sp. (female). All possess a dorsal vessel essentially the same as that found in most members of the subfamily Halictinae.

Subfamily Oxaeinae

Oxaea flavescens Klug (female) has the thoracic portion of the vessel making an arch between the longitudinal muscles of the thorax. The arch is differentiated into ascending, horizontal and descending portions. The descending portion makes a distinctive loop (fig. 8). The thoracic loop is not present.

Family Megachilidae

All members examined from this group agree in having the metasomal ostia located at or somewhat behind the middle of the segments. As in Halictidae and Andrenidae males and females show six metasomal ostia. The thoracic and propodeal ostia were clearly evident in all examined.

Subfamily Megachilinae

Tribe Megachilini

Both *Heriades* (*Physostetha*) *carinata* Cresson (female) and *Heriades* (*Neotrypetes*) *variolosa* (Cresson) (male and female) have the thoracic portion of the dorsal vessel straight.

Megachile (*Litomegachile*) *brevis* Say (male and female) has the thoracic portion of the dorsal vessel making an arch between the longitudinal muscles of the thorax, with ascending, horizontal and descending portions well differentiated. A thoracic loop is present (fig. 9). Another species of *Megachile* from Carmen, Hidalgo, Mexico, was dissected and found essentially the same as in *M. brevis*.

In *Coelioxys octodentata* Say (male) and *Osmia* (*Osmia*) *lignaria lignaria* Say (female) the dorsal vessel is similar to that of *Megachile brevis* but without the thoracic loop.

Tribe Anthidiini

In *Dianthidium* (*Dianthidium*) *sayi* Cockerell (male) the thoracic portion of the vessel is straight, as in *Heriades*. However, in *Anthidium* (*Anthidium*) *maculosum* Cresson (male and female), *Heteranthidium zebratum* (Cresson) (male), and *Paranthidium* sp. (male and female, Taxco, Guerrero, Mex.) the thoracic portion of the vessel makes an arch between the longitudinal muscles of the thorax but lacks the thoracic loop as in *Coelioxys octodentata*.

Family Apidae

All the species dissected of the family Apidae agree in having only five metasomal ostia in both sexes (fig. 10, 11).

Subfamily Anthophorinae

Species of this subfamily have the metasomal ostia located anterior to the middle of each segment, except the first one which is near the middle of the first metasomal segment.

Tribe Exomalopsini

In all the members of this tribe the thoracic and propodeal ostia are clearly evident. In *Exomalopsis* (*Phanomalopsis*) *solani* Cockerell (female), *Exomalopsis* sp. near *diversipennis* Cockerell (female), *Paratetrapedia* (*Trigonopedia*) *oligotricha* (Moure) (male and female, and *Ancylosceles armata* Smith (female) the thoracic portion of the dorsal vessel is straight (fig. 10). On the other hand, in *Monoeca mexicana* (Radoszkowsky) (female) the thoracic portion of the dorsal vessel forms an arch between the longitudinal muscles of the thorax, with the usual ascending, horizontal, and descending sections. The thoracic loop is present. In addition, and unlike any species described above, it has five or six small loops in a series just before entering the thorax (fig. 12).

Tribe Nomadini

In *Nomada* (*Micronomada*) sp. (male, San Luis Potosí, S.L.P., Mex.) the dorsal vessel is essentially the same as that of *Exomalopsis solani*.

Tribe Neopasitini

The dorsal vessel of *Neopasites illinoiensis* (Robertson) (male) agrees with that of *Exomalopsis solani*.

Tribe Epeólini

In *Triepeolus concavus* (Cresson) (male) the dorsal vessel is also essentially the same as in that of *Exomalopsis solani*.

Tribe Emphorini

The following species were dissected: *Ptilothrix sumichrasti* (Cresson) (male and female), *Diadasia diminuta* (Cresson) (female), *Diadasia enavata* (Cresson) (female), and *Melitoma euglossoides* Lepeletier and Serville (female). The thoracic portion of the dorsal vessel in all these forms makes an arch between the longitudinal muscles of the thorax, with ascending, horizontal and descending portions well differentiated. The thoracic and propodeal ostia are clearly evident. The thoracic loop is present.

Tribe Eucerini

In both *Xenoglossa fulva* Smith (male and female) and *Florilegus condignus* (Cresson) (female) the dorsal vessel agrees with the description of that of Emphorini.

In *Xenoglossodes spissa* (Cresson) (female) and *Thygater analis* (Lepeletier) (female) and dorsal vessel, like that of *Monoeca mexicana*, has six small loops in a series just before entering the thorax (fig. 13). The propodeal ostium is not evident in the specimen dissected.

In *Melissodes* (*Eumelissodes*) *coloradensis* Cresson (male and female), *Svastra* (*Epimelissodes*) *obliqua* (Say) (female), *Melissodes* (*Eumelissodes*) *agilis* Cresson (male), and *Peponapis* sp. (female, Iguala, Guerrero, Mexico) the dorsal vessel agrees with the description of *Xenoglossodes* and *Thygater* except that there are only four loops in the series, or, in *M. agilis*, five. (One specimen of *coloradensis* was found with the loop not symmetrically arranged).

Tribe Anthophorini

In *Anthophora* (*Amegilla*) *walshii* Cresson (female) the dorsal vessel, like that of *Monoeca mexicana*, with five loops in the series. Thoracic ostium not evident. Two unknown species of *Anthophora* of other subgenera from Mexico were also dissected, one from China, Nuevo León, and the other from Toluca. They both agree with *A. walshii*. The thoracic loop is apparently lacking in all.

Tribe Centrini

In *Centris vittata* Lepeletier (female) the thoracic portion of the dorsal vessel makes an arch between the longitudinal muscles of the thorax, with the usual ascending, horizontal and descending portions. The thoracic loop is absent, but there is a medium-sized loop before entering the thorax (fig. 15). The thoracic and propodeal ostia are evident.

In *Centris lanosa* Cresson (male) the dorsal vessel agrees with the description of that of *C. vittata*, but the thoracic ostium was not evident in the two specimens dissected.

In *Epicharis elegans* Smith (female) the dorsal vessel is similar to that of *Centris*, but with three loops before entering the thorax (fig. 16). The thoracic and propodeal ostia are evident.

Subfamily Xylocopinae

Tribe Ceratinini

In *Ceratina* (*Zadontomerus*) *dupla* Say (male) the thoracic portion of the dorsal vessel is straight. The thoracic and propodeal ostia are not evident, at least in the specimens dissected. The location of the metasomal ostia is as in the Megachilidae.

Tribe Xylocopini

Xylocopa (*Xylocopoides*) *fimbriata* Fabricius (female), *Xylocopa* (*Xylocopoides*) *virginica* (Drury) (female), and *Xylocopa* (*Neoxylocopa*) *brasilianorum* (Linnaeus) (female) have dorsal vessels like that found in *Svastra obliqua*, forming four loops in a series before entering the thorax. However, the vessel lacks the thoracic loop, the ascending portion almost reaches the notum, and the descending section forms a large loop (fig. 17). The propodeal ostium is not evident.

Subfamily Apinae

All members of their subfamily examined agree by having the location of the metasomal ostia

like that found in Megachilidae. The ostia are located at or behind the middle of their segments.

Tribe Meliponini

Members of this tribe agree in having the last two chambers noticeably enlarged laterally (fig. 19).

Genus *Trigona*

The following species were dissected: *Trigona* (*Tetragonisca*) *jaty jaty* (Smith) (worker); *Trigona* (*Geotrigona*) *mombuca aequinotiales* (Ducke) (worker), *Trigona* (*Dactylurina*) staudingeri (Gribodo) (worker), *Trigona* (*Tetragona*) *nigra paupera* (Provancher) (worker and male), *Trigona* (*Scaptotrigona*) *postica* (*Latreille*) (worker), *Trigona beccarii* Gribodo (worker) *Trigona* (*Plebeia*) sp. (worker), *Trigona* (*Cephalotrigona*) *capitata capitata* Smith (worker), *Trigona* (*Trigona*) sp. (worker).

These all have the thoracic portion of the dorsal vessel straight. The thoracic and propodeal ostia were not or scarcely evident in all specimens dissected.

Genus *Lestrimelitta*

In *Lestrimelitta limao* (Smith) (worker) the dorsal vessel agrees with that of *Trigona* sp.

Genus *Melipona*

The following species were dissected: *Melipona marginata* Lepeletier (worker), *Melipona schencki picadensis* (Strand) (worker), *Melipona scutellaris scutellaris* Latreille (worker), *Melipona beechei* Bennett (worker).

These species all have the thoracic portion of the dorsal vessel making an arch. The thoracic loop is present. There is also a loop in the first metasomal segment before entering the thorax and another smaller loop between the second phragma and the propodeum (fig. 18).

Tribe Apini

The dorsal vessel of *Apis mellifera* Linnaeus (worker and male) is already well known, and little can be added. There are 9 or sometimes 10 loops in the series (18 if counted at both sides). The propodeal ostium was not evident in the five specimens dissected, but the thoracic ostium was usually clearly evident (fig. 20); however, one specimen did not show any indications of the thoracic ostium.

Tribe Bombini

In *Bombus* (*Fervidobombus*) *medius* Cresson (female) the thoracic portion of the dorsal vessel makes an arch between the longitudinal muscles of the thorax. The thoracic loop is absent. The metasomal portion of the vessel makes a gentle curve before entering the thorax. The thoracic and propodeal ostia are evident, and the propodeal one is located on the lower part of the ascending portion of the vessel, between the longitudinal muscles of flight.

In *Bombus* (*Pyrobombus*) *ephippiatus* Say (worker) the dorsal vessel is like that of the previous species but with a large loop in the first metasomal segment before entering the thorax.

In *Bombus* (*Fraternobombus*) *fraternus* Smith (worker) the dorsal vessel is like that of *B. medius* but with a small thoracic loop.

Tribe Euglossini

All the species of this tribe examined agree in having the last two chambers, or more specifically the sixth chamber and the last half of the fifth, greatly enlarged horizontally (figs. 22, 23, 24). The enlarged chambers are well musceled and probably serve as a pumping mechanism. There is a large ostium at each side which opens into the lumen between small flaps (ostial valves).

The chambers are partly filled with large cells, of the same kind found along the metasomal part of the vessel. The thoracic and propodeal ostia were not evident, at least in the specimens examined. The thoracic loop is absent.

In *Euglossa cupreiventris* Cheesman (female) the dorsal vessel, as shown in fig. 21, has six loops in the series before entering thorax. The widths of the two enlarged chambers are twice or more than twice their lengths.

In *Euplusia coerulescens* (Lepeletier) (female) the dorsal vessel is similar to that of *Euglossa cupreiventris* but with apparently four loops in the series. The widths of enlarged chambers are less than twice their lengths.

In *Eulaema dimidiata* (Fabricius) (female) the dorsal vessel is like that of the two previous species, but with only one large loop before entering the thorax and with a loop similar to that found in *Oxaea* in the descending portion of the vessel. The widths of the enlarged chambers are the same as their lengths.

In *Eulaema mussitatus* (Fabricius) (female) only the abdomen was dissected. The enlarged chambers are like those of *Eulaema dimidiata*.

One specimen of *Exaerete smaragdina* (Guér.) was dissected dry; it also seems to have the last two chambers enlarged.

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NOTES ON THE BIOLOGY OF THE ROYAL PALM BUG, XYLASTODORIS LUTEOLUS BARBER (HEMIPTERA, THAUMASTOCORIDAE)[1]

R. M. BARANOWSKI[2]

ABSTRACT

This bug is only known to occur on *Roystonea regia* in Cuba and southern Florida. It lives in the still-folded leaflets of newly emerging palm fronds, and though sometimes plentiful on older trees, it is uncommonly found on younger ones. Eggs are laid among the membranous scales covering the under side of the leaflet midrib, and hatch in 8 to 9 days. Nymphal stages then require an average of 28 days for completion. Males are significantly more numerous than females and are of two types, approximately half having the genital capsule opening to the right, the others to the left. In their confined microhabitat, females generally have one side or the other in contact with plant tissues, so that each one normally is accessible for mating only to one, but not the other, sort of male.

The royal palm bug, *Xylastodoris luteolus* Barber, has caused severe injury in the past to royal palms in Florida. This insect is of interest from several standpoints in addition to its economic potential. It is the only member of its family found in North America; it possesses a most unusual asymmetry of the male genital structures; and even the elementary aspects of its biology are almost unknown. A recent outbreak has provided an excellent opportunity to study the biology of the species and to resolve some of the perplexing questions raised by its peculiar anatomical modifications.

Barber (1920) described *Xylastodoris luteolus* from specimens collected at Santiago de las Vegas, Cuba. Moznette (1921) first reported it as occurring in the United States; at that time it was sufficiently abundant to be destructive to royal palms at Coconut Grove, Florida. There are no records of its occurrence in localities other than Cuba and Florida. In their recent revision of the family Thaumastocoridae, Drake and Slater (1957) reviewed the literature on this species.

Xylastodoris luteolus has been collected in Florida as far north as Vero Beach and Bradenton, and its range in the state is probably co-extensive with the area where its host, the royal palm, is found. Of the four species of royal palms occurring in Florida, *Roystonea regia*, *R. borinquena*, and *R. oleracea* have been introduced from the West Indies, but the second and the third of these are cultivated only to a limited extent, and *R. regia* (a native of Cuba) is the one most widely grown in the state. The native species, *R. elata*, which reaches a height of 90 to 100 feet, is much taller than *R. regia* and, according to Bailey and Moore (1949), is found in the lowlands and swamps of southern Florida. From the keys given by these authors and by Mozingo (1954), it is apparent that *Roystonea regia* is the species of royal palm which is found in the vicinity of the Sub-Tropical Experiment Station and which was used for rearing experiments. This species is distinguished from *R. oleracea* by having the trunk, when mature, conspicuously bulged at some distance above the ground, and from the other two by the presence of prominent lateral veins running lengthwise on either side of the midrib of the leaf segments or pinnae.

Rearing Methods.—Several attempts were made to rear the insects in the laboratory in different types of cages. Shell vials with plastic stoppers, vials with organdy covers, and petri dishes were tried without success. In each case, small pieces of palm leaflets were placed in the cages and were changed daily. Nymphs introduced into these cages did not live more than 4 days. When pieces of leaflets that bore eggs were used, all of the eggs hatched but the first-instar nymphs died within two days. In other experiments, small potted royal palms were brought into the laboratory, and eggs were placed on their leaflets and caged. Again all of the eggs hatched, and again all of the first-instar nymphs were dead by the second day.

Rearing attempts were successful, however, when cultivated royal palms growing on the Station grounds were used. The cages (fig. 1) consisted of organdy tubes approximately 3 inches long and 1 inch wide. These tubes were slipped over the palm leaflets and secured with clamps made of thin pieces of wood (tongue depressors) with sponge rubber glued to one side. The two pieces of wood were held together by U-shaped aluminum clamps.

In the first series of studies, small pieces of plant material bearing eggs were placed between the folded halves of a palm leaflet and caged. The sections of leaflets covered by the cages were cut off and examined daily; then, after examination, a small portion of the leaflet bearing the egg or nymph was cut off and placed on a new leaflet. With this procedure it was not necessary to handle the insects directly, and thus the mortality was reduced. In other series of studies, various

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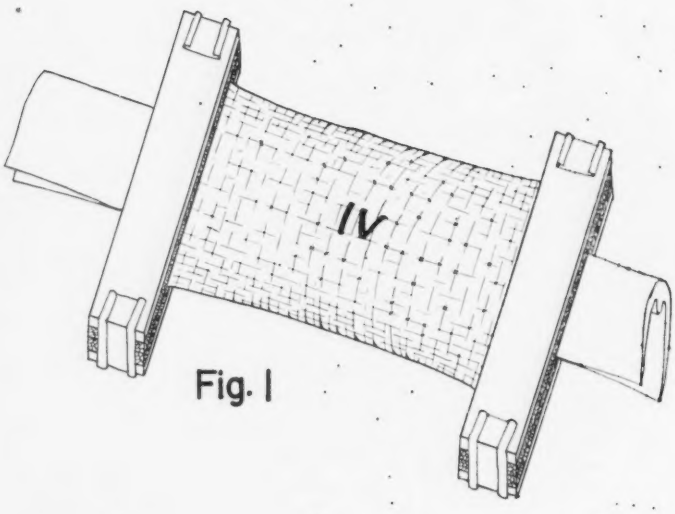

Fig. 1

Fig. 2

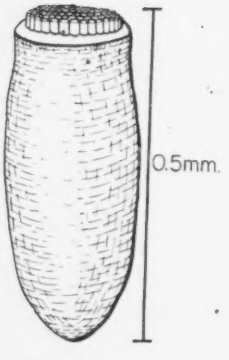

Fig. 3

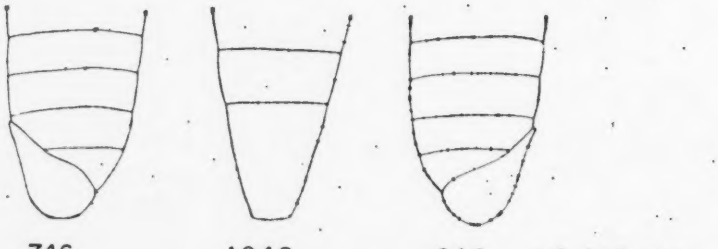

Fig. 4

FIG. 1.—Cage used for rearing *X. luteolus*. FIG. 2.—Portion of royal palm pinna showing type of damage caused by *X. luteolus*. FIG. 3.—Egg of *X. luteolus*. FIG. 4.—Ventral view of terminal abdominal segments. Left—"right-sided" male; center—female; right—"left-sided" male.

instars were taken from naturally infested trees and isolated in cages to get additional data on the duration of each nymphal stadium.

Habitat and Host Injury.—Though other species of royal palms may possibly be affected, *Roystonea regia* is thus far the only known host of *Xylastodoris luteolus*. The insects are found primarily on the newly opened fronds. They occur also on the spike,[3] but not in such great numbers. Moznette (1921) reported that they feed on the developing leaflets while these are still wrapped up in the spike, but this is doubtful. Several spikes on infested trees were opened without finding either the insects or evidence of their feeding. Since the external surface of the spike is made up of the frond midrib and the tightly appressed edges of the leaflets, it is very doubtful if it can be damaged by the feeding of the bugs unless it were injured previously by other agents. The insects do their greatest damage by feeding on the pinnae of the fronds that have most recently broken away from the spike. On fronds such as these, the population is composed primarily of adults. At this stage the pinnae are still folded, but the insects are able to penetrate between the folded halves.

[3]In botanical nomenclature the term spike refers to a particular type of inflorescence. Moznette (1921) used this term to designate that portion of the terminal bud which projects upward above the mature fronds and is made up of very tightly appressed immature fronds. Since the term spike very aptly describes this structure, it will be used here in the sense of Moznette and not with reference to a type of inflorescence.

The damage to the leaflets first appears as small, yellow spots caused by destruction of the cells through withdrawal of the sap (fig. 2). As the leaflets become older they gradually turn brown, and in cases of extensive feeding entire fronds will show these symptoms. In the South Florida area, trees damaged by the royal palm bug tend to have a stratified appearance. The lowest, or oldest, fronds appear brown due to natural aging. Just above them are several fronds that are still green, which developed before the palm bug population had increased sufficiently to cause noticeable damage. Above the green leaves are the brown ones that show extensive damage due to the feeding by the bugs. The uppermost, or new, fronds usually retain their green color for several days.

The royal palm bugs are found principally on larger trees. Several small royal palms, 10 to 12 feet high, were examined in areas where taller trees were heavily infested. Very few specimens were found on them, and no injury to the fronds was visible from the ground. In one locality, large, old trees on one side of a road were heavily infested; on the opposite side, trees less than 20 feet in height had only a few specimens and showed no signs of damage.

The microhabitat of the royal palm bug is such that the insects are out of direct sunlight. If leaflets are unfolded in sunlight or under strong artificial light, the bugs usually move rapidly to the opposite, or shaded, side of the leaflet. They run sideways with surprising agility, and commonly use this type of movement in going over the edge of a leaflet.

Oviposition.—Compared with many other insects, the royal palm bug lays very few eggs. Over a 15-day period, caged females averaged one egg per day each, and none of them produced more than two eggs within a 24-hour period. Although the reproductive system has not been fully studied, preliminary examinations, and the size and number of eggs produced, indicate that each ovary consists of a single ovariole.

The egg is pale tan in color, elongate, 0.5 mm. in length, and is oval in cross section, measuring 0.19 mm. dorso-ventrally and 0.13 mm. laterally. It is capped at one end by a white, "honeycomb" operculum (fig. 3). The first sign of development visible externally appears on the fourth or fifth day, when the red pigmentation of the eyes is evident through the chorion. The eggs hatch 8 to 9 days after deposition.

The eggs are deposited in the membranous scales that cover the under surface of the leaflet midrib. When the leaflet is folded, this covering is on the inside and provides a well-protected site for the eggs. Eggs usually are found singly, though occasionally two occur side by side. Since each female usually deposits only one egg per day, and never more than two, it is quite probable that the eggs occurring in pairs were deposited by different females.

Only one case of egg deposition has been observed. The female backed up along the membranous scales, which are soft and easily pushed aside, probing with the tip of the abdomen until it penetrated the covering. The female then remained in that position until the single egg was deposited.

Nymphal stages.—The royal palm bug molts five times before reaching the adult stage. All

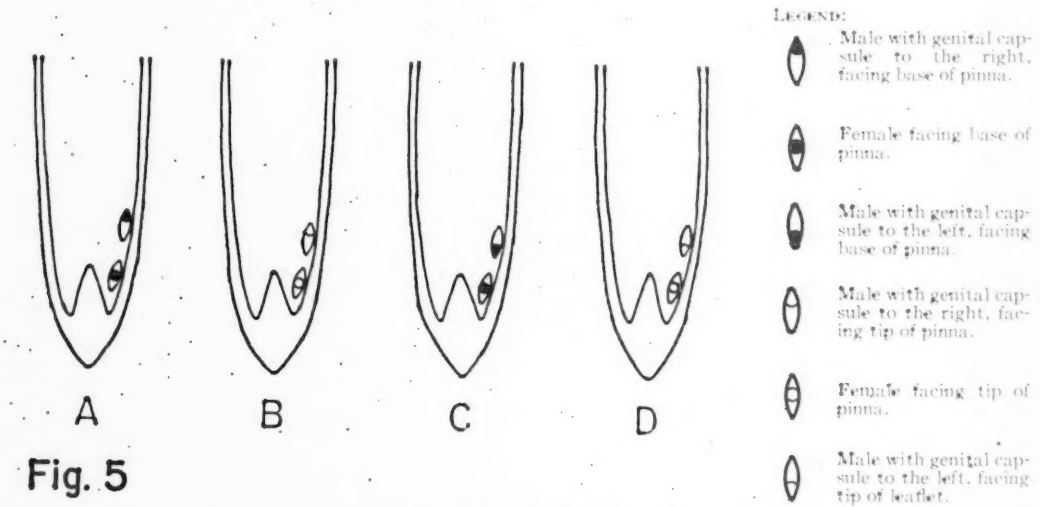
A
B
C
D
LEGEND:
Male with genital capsule to the right, facing base of pinna.
Female facing base of pinna.
Male with genital capsule to the left, facing base of pinna.
Male with genital capsule to the right, facing tip of pinna.
Female facing tip of pinna.
Male with genital capsule to the left, facing tip of leaflet.

Fig. 5

FIG. 5.—Cross section of royal palm pinna showing some possible positions of *N. luteolus*. Pairs in A and B can effect coitus.

of the instars are pale luteous in color, with the eyes red and the apical half of the fourth antennal segment infuscate; and the second, third, and fourth instars also have dark markings on the head and thorax and along the edges of the abdomen. Two dorsal abdominal scent glands, yellow-orange in color, are present in all nymphal instars, although only one appears in the adult stage as surmised by Drake and Slater (1957).

Table 1.—Instar measurements in millimeters.

	1st instar	2nd instar	3rd instar	4th instar	5th instar
Head					
length	0.19	0.21	0.25	0.29	0.36
width across eyes	0.19	0.25	0.32	0.38	0.47
interocular space	0.13	0.21	0.25	0.30	0.25
Antenna					
1st segment	0.04	0.05	0.06	0.07	0.08
2nd segment	0.04	0.05	0.08	0.10	0.13
3rd segment	0.06	0.07	0.09	0.12	0.16
4th segment	0.13	0.13	0.15	0.15	0.19
Labium					
1st segment	0.03	0.03	0.04	0.06	0.08
2nd segment	0.04	0.04	0.06	0.07	0.07
3rd segment	0.14	0.15	0.16	0.18	0.21
4th segment	0.10	0.11	0.11	0.12	0.13
Pronotum					
length	0.09	0.11	0.12	0.15	0.21
width, anterior	0.20	0.27	0.33	0.37	0.48
width, posterior	0.23	0.35	0.44	0.53	0.72
Abdomen					
length	0.30	0.43	0.55	0.67	0.97
Tarsi					
1st segment	0.03	0.03	0.04	0.04	0.07
2nd segment	0.06	0.07	0.08	0.08	0.10
Wing pad					
length	0.07	0.10	0.16	0.27	0.60
Total length	0.71	0.97	1.24	1.48	2.00

The first and fifth nymphal stadia required from 5 to 8 days each, while the second, third, and fourth took from 4 to 7 days. The total time for development, from hatching of the egg to the final molt, ranged from 23 to 37 days, with 28 days as the mean. It is of interest to note that during the period when the royal palm bugs were under observation, from May to September, 1957, new fronds on the palms were produced at about the same rate as new generations of the palm bugs.

Measurements of the instars are given in table 1. Though measurements of four labial segments are given, it should be noted that the differentiation between the first and the second segments is not clear. These segments may have more or less completely fused, resulting in three functional labial segments in this species. Further morphological studies are indicated here.

Reproduction.—The confined microhabitat of the royal palm bug makes it very difficult to observe copulation of these insects. Very often, when a leaflet was opened, pairs in copula were seen. Most of these immediately separated, but in a few cases they remained paired for a few minutes. In these cases the male was dorsal to the female, but to one side. In one instance, a male mounted three females in succession that were lined up along the leaflet midrib, but remained on each one only a few seconds. It is not known whether copulation occurred or not, but the aedeagus was extended when the male left each female.

In determining the sex ratio, 2,443 specimens were examined (table 2). Of these, 1,048 were females and 1,395 were males. Further, the males constituted two groups, 746 of them having the genital capsule modified to open on the right side, 649 on the left side. Figure 4 shows outlines of the terminal abdominal segments of the males.

Drake and Slater (1957) mentioned this modification of the male genitalia and indicated that there is no apparent selective advantage to either direction of male asymmetry. Judging from the ratio of the two types of males, this seems to be true, and both types of males have been seen in copula. But if the genitalia of a particular male are modified to open to the left side, it appears that this male can mount a female only from the right side, while the reverse seems true for "right-sided" males. The observations made on mating pairs, though few in number, bear this out. The male is always slightly to one side or the other, depending on the type of his genitalia.

On observing the insects in relation to their habitat, the occurrence of two types of male asymmetry does appear to have a definite advantage over only one type. The fact that there are significantly more males than females also tends to support this. Under the hypothesis that a 1:1 ratio exists between males and females, a chi-square value of 49.28 is derived, which is highly significant against this ratio and indicates that the population does normally have more males than females. Assuming a 1:1 ratio between the two types of males, the deviation in the actual count is insignificant, as the chi-square value of 3.37 falls below the 0.05 level. On examining the data for the possibility of either a 6:4 ratio between males and females, or a 3:3:4 ratio between the two types of males and the females, values of 8.55 and 14.97 are derived, respectively. Both of these values are highly significant against the ratios. When the data were examined for a 2:2:3 ratio, a value of 6.74 is derived, which is significant against the ratio at the 0.05 level but insignificant at the 0.02 level. The important considerations are that the number of males is significantly higher than the number of females and that the two types of males are significantly equal in numbers.

TABLE 2.—Sex ratio of *X. luteolus* Barb.

Location	Collection Date	Sample Size	No. of Females	No. of "Right-sided" Males	No. of "Left-sided" Males	% Females
Coconut Grove, Fla.	V–23–57	59	25	21	13	42.4
Homestead, Fla.	VIII– 8–57	57	13	22	22	22.8
" "	VIII–13–57	618	244	205	169	39.5
" "	VIII–19–57	705	321	204	180	45.5
" "	VIII–20–57	385	162	117	106	42.1
" "	IX–20–57	619	283	177	159	45.7
		2,443	1,048	746	649	42.9
				1,395		

It was stated above that the eggs are deposited between the folded halves of the palm leaflets. Mating has been observed only between the folded halves of the leaflets, and the majority of the specimens are found in this location. Hence it can safely be assumed that most of the mating occurs here. The folded leaflets offer quite a confined microhabitat; quite often the halves are appressed, or nearly so, at one or more points. The insects appear to prefer the more confined areas. They tend to line up along the midrib, and in the cages most of the feeding punctures were located near the clamps where the halves of the leaflets were held tightly together.

On considering the habits of the species and its habitat, it is evident that most of the individuals have one side near or against some part of the leaflet, and this will occur whether they are along the midrib or on the halves of the leaflets where these come together. Further, since adjacent leaflets lie against each other in this stage of development, the same conditions are present if the insects are on the upper surfaces of the leaflets. In view of this, it seems evident that very often one side of the female is obstructed, and when a female is in a position such as this, the advantage of the two types of male asymmetry becomes apparent. If the female is facing the base of the leaflet (fig. 5, A, C), with her right side obstructed, only a male with the genital capsule opening to the right can get into a position to effect coitus. If this female were facing in the opposite direction, the reverse is true (fig. 5, B, D). If all of the males of *X. luteolus* had the genital capsule opening to the same side, it would appear that the possibility of many females remaining unmated would be much higher than is the case.

Although the insects remain for the most part between the folded leaflets and do not appear to move about very much, this hypothesis does not necessitate a sedentary habit. In any event, the insects are between two surfaces and usually are in contact with a part of the leaflet.

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THE APHIDOIDEA OF THE MIDDLE EAST, by F. S. BODENHEIMER AND E. SWIRSKI. 378 pp., 52 figs. The Weizmann Science Press of Israel, Jerusalem, 1957. Clothbound. Price not stated.

This is the first comprehensive volume published on the aphids of the Middle East, and the first to deal with the aphid fauna of an arid and semiarid region existent in a subtropical climate. The publication gives attention to various aspects of aphid study including among others, biology and ecology, life cycles, life histories, dispersal and distribution, populations, nutrition, damage and control, terminology, taxonomy, and bibliography.

The authors arrange the 207 species that are known in the Middle East by systematic groups, and give a limited number of literature citations, the hosts, the distribution in the Middle East and elsewhere, and a brief statement on the life history of the various species. The aphids are also listed under the host plants on which they occur. There are keys to the species and higher groups represented in the fauna. Although some of the scientific names and categories used will not be accepted universally, this fact does not detract materially from the value of the publication.

The figures are composed of graphs, charts, photographs, and line drawings, and in general are adequate for the purpose for which they are intended.

This work will be of especial assistance to workers concerned with aphids of the Middle East, and to other persons who are interested in aphids existing under conditions comparable to those of that area.

LOUISE M. RUSSELL

DESCRIPTIONS OF THE LARVA AND ADULT FEMALE OF PHOROSTOMA TABANIVORA (HALL) (DIPTERA: LARVAEVORIDAE) AND NOTES ON THE BIOLOGY OF THE SPECIES[1]

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ABSTRACT

Descriptions are given of the larva and adult female of this species, known previously only from Minnesota and here reported from Wisconsin and northwestern Michigan. In Michigan it was found to parasitize 16% of the tabanid larvae collected in sphagnum bogs, its most frequent host being *Hybomitra trepida* (McD.). Parasitic larvae developed in tabanids over the winter, presumably from eggs laid in the fall; and the hosts were killed in the following spring, when the parasites emerged.

Literature records few parasites of the larvae of North American Tabanidae. Most of these reports involve single parasite records and almost nothing is known of their life histories or ecologies. The members of the Larvaevoridae lay their eggs in the larval habitat of the host and the tiny larvae seek out the host and enter it.

Pharostoma tabanivora was described by Hall (1937) from a single male reared by C. B. Philip from a larva of *Tabanus trimaculatus* P. de B. The parasitized tabanid larva was collected along the margin of a woodland pool in Ramsey County, Minnesota (Phillip 1931). Greene (1937) described the pupal case from this collection: A second parasitic larva was collected by Philip from the larva of *Hybomitra lasiophthalma* (Macq.) in Anoka County, Minnesota. This larva died without pupating. The only other specimen of this species known was reported from Dane County, Wisconsin (Sabrosky 1957, personal communication). During 1955 and 1956, numbers of this species were encountered during an ecological investigation of the Tabanidae of the Ottawa National Forest in the western end of the upper peninsula of Michigan.

During this ecological investigation, 252 tabanid larvae were collected from sphagnum bogs. Forty of these larvae were parasitized by *P. tabanivora*. In situations other than bogs parasitism was negligible except in cases where tabanid larvae were living in loose mats of dead grasses or other matted vegetation.

Parasitized tabanid larvae collected early in May showed no obvious external symptoms of parasitism. The first signs of parasitism were a lethargic condition of the larva, formation of excess liquids within the body cavity, and refusal to feed. Shortly thereafter the larva died. By this time, the entire body contents of the tabanid, except the chitinous parts, had been liquified. Only one parasite was found in any one host individual. The full grown parasitic larva of *P. tabanivora* filled two-thirds of the body cavity of the parasitized tabanid larva. The parasitic larva was in almost constant motion. Peristaltoid movements were clearly evident in the musculature of the parasite and it moved from one end of the tabanid larva to the other at about 5-minute intervals.

In the present investigation it was found that the pupa may be formed either inside or outside of the parasitized tabanid. The usual procedure was for the larva of *P. tabanivora* to pierce the skin of the tabanid in the head region and emerge before forming the pupa. The puparium was formed inside the last larval skin as in other muscoid Diptera. The period of pupation was from 15 to 18 days.

Oviposition by *P. tabanivora* was not observed in nature. However, the loose nature of the sphagnum in which the parasitized larvae were found supports the belief that the adult parasite may actively seek out the host larva and oviposit upon it. Since parasitized larvae were collected before the spring thaw, it is believed that this parasitic species probably passes the winter as a small larva inside the tabanid host. Evidently this parasitism did not affect the growing tabanid since the size range of parasitized and non-parasitized tabanid larvae was the same. Only a few dead larvae were found in the field. Only two of these had been parasitized and the parasites had emerged before they were found.

Of the larvae collected, most of the parasitized were *Hybomitra trepida* (McDunnough); however, two other species of *Hybomitra* were parasitized, as well as one *Chrysops* larva.

Phorostoma tabanivora (Hall)

LARVA

(Figures A, B, C, D)

Larva (fig. A).—Length 17 mm. Large, creamy

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white, nearly cylindrical, and tapering slightly toward each end, widest at the level of the fifth segment. Eleven segmented, segmental lines distinctly marked. Integument spiculose. Mouthhooks (fig. B) dark brown, and heavily sclerotized. The anterior spiracles (fig. C) black, ellipsoid, faintly four-lobed, arising between segments one and two; covered with small, light brown, oval, raised areas. Posterior spiracles (fig. D) black, elevated, narrowly separated. Spiracular plates irregularly D-shaped, ventral border on horizontal axis of 11th segment. Spiracular openings medianly located in hemiovate proturbances from the spiracular plate. Anal opening located in ventral one-fourth of the 11th segment. Opening slit-like and covered by a fleshy upper lip.

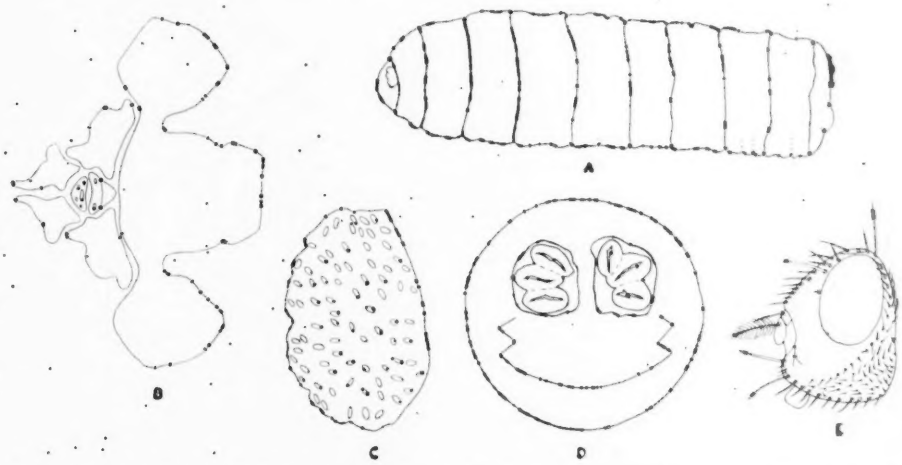
Described from a single larva taken from *Hybomitra* sp., Houghton County, Michigan, Hope's Creek, 1 June, 1956. Other larvae reared to adulthood. This larva, along with the excised and mounted mouth-hooks, now in the U. S. National Museum.

stained with yellow. Proboscis black, about twice as long as palpi. Palpi dark brown. Post ocular bristles well developed, in rows.

Thorax black with silvery gray pollen. Dorsum of thorax with four distinct silvery gray stripes. Humeral bristles 3, notopleurals 3, postalars 3, dorsocentrals 8, intra-alars 6, supra-alars 3, lateral scutellars 4, apioscutellars 1, discoscutellars 1. Mesopleural bristles 6, pteropleural bristles 3, sternopleural bristles 2, and hypopleural bristles 6.

Wings normal, hyaline. Legs black, fore- and mid-tibiae with two posterior bristles and an anterior row of bristles, hind tibia with one anterior bristle and two posterior-lateral rows of bristles. Halteres brown, darkened apically.

Abdomen black, thinly grayish pollinose, with numerous setae, those on the posterior margin of the fourth abdominal segment larger and bristle-



A—Lateral aspect of larva. B—Mouth hooks of larva, dorsal aspect, flattened out. C—Prothoracic spiracle of larva. D—Posterior aspect of eleventh segment of larva. E—Lateral aspect of the female head.

ADULT FEMALE

Female (fig. E).—Length 8–10 mm. Head length one-third longer than lateral width, from a cephalic aspect length and width equal. Front twice width of eye, dark brown in the center, silvery gray on lateral margins. Ocelli three, located in a prominent tubercle at the vertex. Ocellars, one pair on the ocellar triangle, two pairs laterad; frontals eight in number; four pairs of fronto-orbitals. Antennae black, third segment 1½ to 2 times the length of the second segment. Oral vibrissae composed of 10 strong and several secondary setae. Genae silvery-gray

like. Posterior border of fifth abdominal segment and ovipositor red.

Allotype: Gogebic County, Michigan, 4 July 1956.

Described from five females from Iron, Gogebic, and Houghton Counties, Michigan. Allotype in the U. S. National Museum, other females in the collection of the author.

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EFFECTS OF DDT ON THE BLOOD OF TENEBRIO MOLITOR LINNAEUS[1]

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ABSTRACT

Biochemical determinations on the blood of the mealworm, *Tenebrio molitor*, show that exposure to DDT resulted in no change in protein nitrogen, 50 percent increase in non-protein nitrogen, 90 percent increase in reducing compounds, and 70 percent increase in amino nitrogen. Chromatographic determination showed a comparable 60 percent increase in the amino nitrogen. Eighteen amino compounds were separated and identified chromatographically with phenol butanol-acetic acid, collidine and lutidine as solvents. They are alanine, aspartic acid, cysteine, glycine, glutamic acid, histidine, isoleucine, lysine, methionine, norleucine, ornithine, phenylalanine, proline, serine, taurine, threonine, tyrosine and valine. Most of the compounds increased as a result of DDT poisoning, but norleucine and taurine decreased. Since changes obtained in the blood of insects due to starvation and DDT poisoning are similar, it is likely that the starvation which follows DDT poisoning is the cause of death of the insect.

The cause of death resulting from the application of DDT to insects is not clearly understood, even though there are indications that it may be interference with enzyme systems or starvation. The work of Buck and Keister (1949) indicates that DDT might interfere with an enzyme system needed for the utilization of fat. Sacktor and Bodenstein (1952), Morrison and Brown (1954), and Ludwig, Bärsa and Cali (1955) showed that when DDT is applied in vitro, it inhibits cytochrome oxidase. Johnston (1951) showed that DDT inhibits the succinic oxidase system in the rat; while Pant and Dahm (1957) reported inhibition of succinic dehydrogenase and overstimulation of glycolysis. Sacklin, Terriere and Remmert (1955) stated that it inhibits the oxidation of citric acid cycle intermediates and oxidative phosphorylation, while Tomizawa and Fukami (1956) found no such change.

Ludwig and Bartolotta (1953) showed that in the Japanese beetle, *Popillia japonica*, the changes which occur in the blood of the larva after exposure to DDT are very similar to those reported by Ludwig and Wugmeister (1953) in this insect following four weeks of starvation. They include an increase of non-protein and amino nitrogen and of reducing compounds. Po-Chedley (1956), using larvae of the Oriental beetle, *Anomala orientalis*, showed an increase of amino nitrogen in the blood from 179 in the normal to 320 mg. percent in others starved 4 weeks. He also showed an increase in most of the amino compounds of the blood during starvation. The present experiments were undertaken to determine the changes that might occur in the composition of the blood of the mealworm as a result of exposure to DDT and to compare them with those obtained in other insects during starvation.

MATERIAL AND METHODS

Mealworm larvae were obtained from a culture kept at room temperature (approximately 25° C.). They were etherized for 15 minutes to prevent blood coagulation. The fore-legs of the larvae were cut and the clear transparent blood collected in the depression of a porcelain spot plate. It was measured with a 0.1-ml. pipette and 0.1 ml. was used for each determination. The larvae were poisoned by allowing them to crawl for two minutes on a piece of filter paper moistened with 5 percent DDT in peanut oil. The larvae lived approximately 5 days and blood was taken 3 days following exposure.

Biochemical determinations of protein and non-protein nitrogen were made by the micro-Kjeldahl procedure. The concentration of the reducing compounds was determined according to the procedure of Hagedorn and Jensen as outlined in Hawk, Oser and Summerson (1951). Measurements of the amino acid nitrogen were made according to the method of Frame, Russell and Wilhelmi (1943). The separation and identification of the free amino acids of the blood were accomplished by paper partition chromatography according to the procedure of McFarren (1951). For quantitative work, the method of McFarren and Mills (1952) was adopted. The solvents used were phenol (unbuffered and buffered at pH values of 6.2 and 12), butanol-acetic acid-water (unbuffered and buffered at pH 6.2), meta-cresol buffered at pH 8.4, collidine and lutidine (both unbuffered). Whatman No. 1 filter paper was used for chromatographic work. Color was developed by spraying the paper with ninhydrin, except for proline, where isatin was used.

OBSERVATIONS AND RESULTS

The results of the biochemical determinations on the blood of the normal and poisoned larvae are shown in table 1. Protein nitrogen values in the blood of the normal and DDT poisoned

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Table 1.—Changes in the composition of the blood during DDT poisoning

	Protein nitrogen	Non-protein nitrogen	Total nitrogen	Reducing compounds	Amino nitrogen
			Normal larvae		
Number of tests	5	5	5	12	10
Minimum values	738 3	304 1	1112 4	71 4	100 1
Maximum values	990 5	486 2	1476 6	136 2	151 1
Average values	886 9	422 1	1309 0	103 0	118 4
			DDT-poisoned larvae		
Number of tests	5	5	5	12	5
Minimum values	794 4	591 2	1504 7	165 0	164 5
Maximum values	1220 3	682 3	1869 9	251 9	231 1
Average values	903 6	632 4	1536 0	196 1	200 1

larvae were 887 and 904 mg. percent, respectively, showing an insignificant increase of 2 percent. Corresponding values expressed in mg. percent for non-protein nitrogen were 422 and 632, an increase of 50 percent; for reducing compounds 103 and 196, an increase of 90 percent; and for amino acid nitrogen 118 and 200, an increase of approximately 70 percent.

Table 2.—Total amino nitrogen and percentage change as a result of exposure to DDT.

Amino compound	Amino nitrogen in mg. percent		Increase or Decrease mg. percent	Percent Change
	Normal	DDT-Poisoned		
alanine	5 7	28 7	+23 0	+400
aspartic acid	2 1	3 7	+ 1 6	+ 76
cysteine	Trace	Trace	Trace	Trace
glycine	6 4	7 9	+ 1 5	+ 23
glutamic acid	2 4	6 8	+ 4 4	+183
histidine	4 7	11 5	+ 6 8	+144
isoleucine	6 3	7 3	+ 1 0	+ 16
lysine	14 4	15 0	+ 0 6	+ 4
methionine	4 5	10 0	+ 5 5	+122
norleucine	16 5	11 9	− 4 6	− 28
ornithine	5 8	11 8	+ 6 0	+102
phenylalanine	Trace	Trace	Trace	Trace
proline	21 6	56 0	+34 4	+159
serine	3 8	6 5	+ 2 7	+ 71
taurine	27 0	19 0	− 8 0	− 29
threonine	Trace	Trace	Trace	Trace
tyrosine	Trace	Trace	Trace	Trace
valine	5 7	8 5	+ 2 8	+ 49
Total	126 9	204 6		

Eighteen amino compounds were separated and identified by paper partition chromatography in the blood of normal mealworm larvae. They are shown in table 2 together with the changes which occurred following exposure to DDT. Each figure is an average of at least six determinations. Most of them increased as a result of DDT poisoning, the exceptions being norleucine and taurine, where decreases were obtained. The amino nitrogen obtained by chromatography was 126.9 mg. percent for normal and 204.6 mg. percent for poisoned larvae. Poisoning the larvae thus resulted in an increase of 60.3 percent as measured by paper chromatography.

DISCUSSION

The physiological effects of starvation and DDT poisoning are very similar. Ludwig (1950) showed that the nymphs of the grasshopper, *Chortophaga viridifasciata*, lost 97 percent of their glycogen and 69 percent of fat during the complete starvation, there being no change in protein nitrogen. Similar results were reported by Newton (1954) on the larvae of the Japanese beetle, *Popillia japonica*. He found that 80 and 71 percent of glycogen and fat, respectively, were lost during four weeks starvation.

As a result of exposure of *Phormia regina* to DDT, Buck and Keister (1949) found that the flies which died due to DDT had more respirable substrates left than starved controls. However, Ludwig (1946) showed that at the time of death due to DDT poisoning, Japanese beetle larvae had used 85.5 percent of the original supply of glycogen, 40.4 percent of glucose, and 32.8 percent of the fat. Comparable figures obtained by Newton (1954) during the starvation of this insect were 80.0, 28.6 and 71.7 percent respectively. Therefore, it is clear that more of the available carbohydrate reserve is utilized following exposure to DDT than during starvation. Ludwig (1946) also observed that a much larger percentage of fat remained in the larvae at the time of death due to DDT than following complete inanition. Therefore Ludwig and Bartolotta (1953) suggested that DDT might interfere with an enzyme system needed for utilization of fat. According to these authors, the inability to use this large percentage of fat might explain the

greater use of carbohydrate as energy source following exposure to DDT.

The results of the present investigations on the effects of DDT for the blood of the mealworm show changes similar to those reported by Ludwig and Bartolotta (1953) for the blood of the Japanese beetle following exposure to DDT. The changes occurring in the individual amino acids of insect blood following exposure to DDT are also very similar to those occurring during starvation. In the Oriental beetle, *Anomala orientalis*, as a result of starvation (Po-Chedley, 1956), and in the mealworm following exposure to DDT (present experiment), great increases in amino nitrogen were obtained for alanine, aspartic acid, glutamic acid, histidine, methionine, proline, serine and valine. Increases in both cases were also observed for glycine, isoleucine and lysine. The only exception was taurine which increased slightly in the Oriental beetle during starvation and decreased in the mealworm as a result of exposure to DDT. Therefore it appears that starvation which follows DDT poisoning is the cause of death. The recent work of Beard (1957 and personal communication, 1958) on the effects of DDT on larvae of the bee moth, *Galleria mellonella*, confirms this conclusion. Beard states that in the normal course of toxication, the insect may die of physical exhaustion due to hyperactivity which accompanies DDT poisoning. Beard also reported that prompt and complete recovery from the effects of DDT was obtained in some larvae when energy substrates or energy rich substances were administered.

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THE MELON LEAF MINER, LIRIOMYZA PICTELLA (THOMSON) (DIPTERA: AGROMYZIDAE)[1]

EARL R. OATMAN[2] AND A. E. MICHELBACHER[3]

ABSTRACT

This fly, widespread at lower elevations in California, does great damage to various agricultural crops in the San Joaquin Valley, principally by the mining of the larvae within the leaves but also through the punctures made by females for feeding and oviposition. It appears to overwinter as pupae in the soil and in host plant debris. Adults appear in April and peak populations, in August, may be extremely large. Under greenhouse conditions, adults emerge from pupation during morning hours, with females about 5% more numerous than males. Mating usually occurs within 24 hours, and oviposition is begun 12 to 24 hours after mating. Eggs are usually laid in the mornings and are placed in the upper surface of the host leaf. Fertile eggs per female in constant association with males averaged 688 (range, 1 to 1425), reaching 35 to 40 per day after a few days, remaining at that level for a week or more, then declining to 3 to 5 per day at the end of 30 days. Adults feed largely on exudations from wounds in the plant tissues made by the females with their ovipositors, about five-sixths of such wounds being used only for feeding, the others for oviposition. Adults (especially males in absence of females) also feed on natural exudations from the plants. The adult life span of males averaged 28 days (range 13 to 45); of females constantly associated with males, 42 days (range 17 to 57); of females separated from males, 6 days less. Larvae form serpentine mines as they feed, usually in the palisade layers of the leaves. Mature third-instar larvae average 2.24 by 0.55 mm. These mature larvae emerge from the leaves, usually between 6 and 7 a. m. A few may pupate on the host plant, but most of them drop to the ground and burrow in a few centimeters. Pupation requires 20 to 30 minutes, the final molt forming the puparium which averages 1.49 by 0.73 mm. Under greenhouse conditions the duration of the pupal stage was 9 days (range 7 to 11).

I. LIFE HISTORY STUDIES

The melon leaf miner, *Liriomyza pictella* (Thomson), is probably the most common and destructive leaf miner in California. It has become increasingly important within the last decade as an economic pest on melon, bean, alfalfa, and other cultivated crops in the agricultural areas of the state. It is apparently a native species. Damage is caused by the mining of the larvae within the leaf tissue and by the feeding and oviposition habits of the female.

The leaf miner is reduced to relatively low numbers under natural field conditions by hymenopterous parasites (Michelbacher *et al.* 1951, 1952, and 1955). However, under favorable environmental conditions the population of *L. pictella* may reach extremely high numbers. There is some evidence that the widespread use of DDT has been responsible for the increase of this insect and other closely related species. Apparently, the use of DDT has had an adverse effect upon certain natural enemies (Mayeux and Wene, 1950; Wene, 1953 and 1955; Hills and Taylor, 1951 and 1953; Michelbacher *et al.*, 1951, 1952, 1953 and 1955).

The literature which concerns *L. pictella* is not extensive. According to Frick (1957), the first publication that definitely dealt with this species is that of Lange (1949), in which he referred to it as *Agromyza* (*Liriomyza*) *subpusilla* Frost. Lange reported that the species caused economic damage to alfalfa, beans, melons, and tomatoes in the San Joaquin and Sacramento Valleys of California during the fall of 1948. The first economic investigations were conducted by Michelbacher *et al.* (1951) who referred to *L. pictella* as *Liriomyza* sp. These workers observed that it was responsible for economic damage on several varieties of melons in the central and northern sections of the San Joaquin Valley of California. In a later paper, Michelbacher *et al.* (1952) reported on the destructiveness of the pest and conducted field observations dealing with its biology and control. More recently Michelbacher *et al.* (1955) reviewed the literature concerning the insect, and reported on the economic aspects of the problem.

Investigations of the biology and ecology of the melon leaf miner were undertaken in 1954, for the purpose of gaining an understanding of the factors responsible for its rise in economic importance. The results of the biological phases of the study are presented in this paper.

TAXONOMY AND SYNONOMY

The genus *Liriomyza* was originally erected by Mik in 1894 for the species *L. urophorina* Mik, which has a basal segment of the female ovipositor nearly as long as the abdomen. In addition to having this common morphological character, the species in the genus form a very homogeneous group, with practically the same structure and coloration as the type species (Frick, 1952).

Frick (1957) proposed *L. pictella* as a new

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combination. The synonomy of the species is as follows:

Agromyza pictella (Thomson), 1868 Dipt. Freg. Eugen. Resa, (2) 6(12): 609.
Agromyza (Liriomyza) subpusilla Frost p. p., Lange 1949, Pan-Pacific Ent. 25: 91.
Liriomyza sp.: Michelbacher *et al.*, 1949, Jour. Econ. Ent., 42: 666; Michelbacher *et al.*, 1955, Univ. Calif. Agric. Expt. Sta. Bull. 749: 28 (figs. of mined leaves).
Liriomyza subpusilla Frost p. p.: Michelbacher *et al.*, 1951, Jour. Econ. Ent., 44: 390 (fig. of mined melon leaf); Michelbacher *et al.*, 1952, *ibid.*, 45: 470.

The holotype male, collected in California, is deposited in the Naturhistoriska Riksmuseum, Stockholm, Sweden. Other specimens of this species, including 22 males and 16 females, were reared from infested cantaloupe leaves collected at Oro Loma, California, by K. E. Frick in 1948. These are deposited in the collections of the California Insect Survey, California Academy of Sciences, U. S. National Museum, State College of Washington, Zoologische Museum in Berlin, and in K. E. Frick's personal collection (Frick, 1957).

DISTRIBUTION

Because of the insufficient knowledge of the *Liriomyza* complex it is difficult in some instances to give the exact distribution of the species. This certainly appears to be the case with *L. pictella*. At the present time the only accurate distribution record is that given by Frick (1956) who recorded it from the following localities: Yuba City and Robbins in Sutter County; Marysville in Yuba County; Vernalis in San Joaquin County; Patterson, Wesley and Crows Landing in Stanislaus County; Dos Palos in Merced County; Oro Loma in Fresno County; Berkeley in Alameda County; Mountain View, Sunnyvale, and Meridian in Santa Clara County; Laurel, Aptos and Santa Cruz in Santa Cruz County; Salinas in Monterey County; Santa Ana in Orange County; and Indio in Riverside County.

This distributional record suggests that *L. pictella* has a wide general distribution throughout California, particularly at the lower elevations. The full extent of the distribution of the species will be difficult to ascertain because of its similarity to closely related species.

METHODS AND MATERIALS

A stock culture of melon leaf miners was started in the greenhouse in July, 1954, from infested Cranshaw melon leaves collected at Patterson, California. These were placed in a large redwood-framed cage, 2½ x 3 x 3 feet, and covered with lawn cloth. The cage was provided with a cloth sleeve in the front and had a slatted redwood floor. The leaf miner completed its development and continued to reproduce on the Persian melon plants provided as hosts.

It was determined through experimentation that the Henderson bush variety lima bean plant was an ideal experimental host for the melon leaf miner. It was therefore used in all subsequent studies. Fresh plants of this variety were provided for the stock cultures as the old ones approached defoliation. When the adults reached extremely high populations the excess was removed with a vacuum device.

All the flies used in the investigations were obtained from a single fertilized female of *L. pictella*.[4]

Life history and ecological studies were carried out on the Berkeley campus of the University of California in a section of a greenhouse having a southeast exposure. The room was steam-heated and the thermostat was set at 26.7° C. throughout the investigation. The temperature and relative humidity were recorded continuously on a Friez hydrothermograph located in the center of the room at the same level as the experimental plants and cages. The temperature ranged from 14.4° to 37.2° C. with an average of 25.5° and the relative humidity ranged from 22% to 54% with an average of 38.3%. All plants used during the experiments were grown and maintained in this room under the best possible cultural conditions.

Cylindrical oviposition cages, 6½ x 12 inches, were constructed from sheets of cellulose acetate. The tops were covered with lawn cloth and secured by the rim of the lid of a half-hallon ice cream carton, which had been cut off at a height of 1 inch. Two 1-inch circular holes were cut into each side of the cage, approximately 4 inches from the bottom. These were covered with lawn cloth to provide ventilation. A hole ½ inch in diameter was cut into the center of the side of the cage and fitted with a cork stopper. This opening was used for the introduction of a syringe for watering the plant, or to introduce adults into the cage.

The oviposition cages were used in all the biological investigations conducted under greenhouse conditions involving living plants. When it was necessary to replace a plant, the oviposition cage was placed directly beneath a light. The positively phototactic adults flew to the top of the cage when the plant was disturbed or when air was blown into the cage. The cage was then removed from the bottom section and placed over a folded square of cloth. The old plant was exchanged for a new one and the cage replaced into the bottom section. This entire operation had to be performed quickly and smoothly to keep the adults from escaping.

Two-dram, patent-lipped vials were utilized in experiments involving studies of individual mature larvae and pupae.

Adults used in mating, longevity, and oviposition tests were taken as they emerged from

[4]The specimen was subsequently identified by Dr. K. E. Frick.

individual 2-dram vials and placed directly into the oviposition cages without unnecessary handling. This was accomplished by inserting the end of the vial into the ½-inch diameter opening and tapping the bottom of the vial until the fly flew into the cage. Each cage was examined daily for dead adults, which were removed, sexed, and recorded.

Mature larvae and pupae were obtained for the various tests by placing the mined plants 12 to 18 inches apart on a cloth-covered table. Folded paper toweling was placed beneath and around the potted plants to provide pupating sites for the emerging larvae. The mature larvae or pupae were collected early each morning with a camel-hair brush.

Seasonal activities of the melon leaf miner were followed under field conditions at several locations near Patterson and Vernalis, California, during 1954 and 1955.

DESCRIPTION OF STAGES

Egg.—The egg of *L. pictella* is opalescent, ellipsoidal, with a thin, transparent chorion which is devoid of surface sculpturing (figure 2). It averages 0.23 by 0.13 mm. (table 1).

Larva.—The larva is somewhat cylindrical and typically maggot-like. The anterior end tapers and the posterior end is truncate (figure 1). The average size of mature or third instar larva is 2.24 by 0.55 mm. (table 1). The first-instar larva is hyaline when newly emerged, soon becoming a faint green as it commences feeding upon the leaf tissue. The second instar larva is light yellow-green, whereas the third-instar larva becomes a richer yellow-green, with most of the yellow color in the anterior portion. The dark green chlorophyll-like matter in the intestines is clearly visible in this instar.

The body of the larva consists of a head region, three thoracic, and eight abdominal segments.

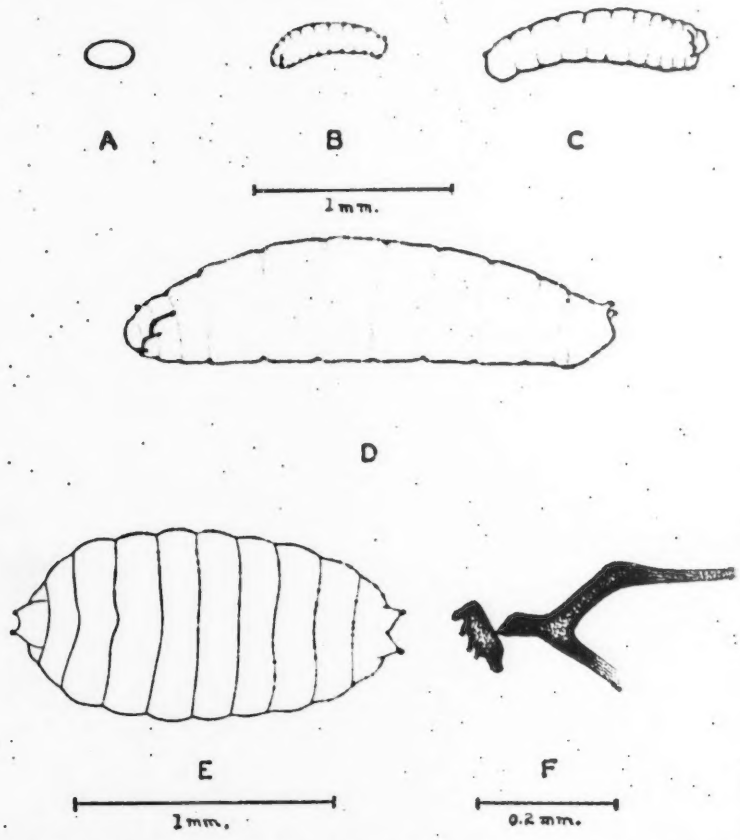

FIG. 1.—Immature stages of the melon leaf miner, *Liriomyza pictella* (Thomson): (A) egg; (B) first instar larva; (C) second instar larva; (D) third instar (mature) larva; (E) pupa; (F) black sclerotized mouth-hooks of third instar larva.

There is an anal opening ventrally on the last abdominal segment and an oral opening ventrally in the head region. The teeth of the black sclerotized mandibles, or mouth hooks, extend into the oral opening. The mandibles are united at the base and appear to work together as a unit. There are two well-developed teeth on each mandible, but because they are slightly offset, there appear to be four teeth in a lateral view (figure 1). The mouth hooks are clearly visible in all instars. The larva possesses bands of minute cuticular processes relative to the areas of segmentation, being strong in some and weak in others. The first-instar larva apparently has only posterior spiracles, whereas the second and third instars have a posterior pair of spiracles situated dorsally on the eighth (last) abdominal segment and a smaller, anterior pair located dorsally on the prothorax (figure 1).

TABLE 1.—Measurement in millimeters of egg, mature larva, pupa, and wing length of adult male and female of *Liriomyza pictella* (Thomson).

Stage[a]	Width		Length	
	Range	Average	Range	Average
Eggs	0.12–0.14	0.13	0.20–0.25	0.23
Mature Larvae	0.45–0.60	0.55	0.17–0.26	2.24
Pupae	0.60–0.80	0.73	1.30–1.80	1.49
Adult (male wing)	———	——	1.15–1.45	1.30
Adult (female wing)	———	——	1.35–1.63	1.50

[a]Measurements based upon 25 individuals.

Pupa.—The third-instar larval skin forms the puparium, in which the pupal stage is formed. The puparia average 0.73 mm. by 1.49 mm. (table 1). At first the puparium is a rich golden-yellow color turning to a darker reddish-brown as transformation to the adult takes place. The puparium (figure 1), is distinctly segmented, subcylindrical, with lateral sides subparallel and tapering rather sharply at the ends, flattened ventrally and arched dorsally. The mouth hooks, spiracles, and cuticular processes are clearly visible. After the adult emerges, the empty puparium is a light amber, rather brittle structure, with a torn dorsal lid-like section left hanging open at the anterior end. A hyaline, soft, pliable sac, which enveloped the developing adult, is left inside the puparium. The posterior end of this sac has a crumbly, milky-white cap.

Adult.—The two sexes are distinguished visibly, the female being larger and more robust than the male (figure 2). Further, the female's terminal abdominal segment extends into a black, telescoped, ovipositor-like organ. The ventral abdominal segments of the female are shaded with black, those of the male are only faintly black, with dark-brown, button-like terminalia on the posterior abdominal segment. The average length of the female wing along its longitudinal axis is 1.50 mm., whereas that of the male is 1.30 mm. (table 1).

The living adult is shiny yellow and black. The head is yellow except for the ocellar triangle and the back of the head, which are black; eyes magenta-red. The dorsum of the thorax is blue-black with the sides orange yellow, patterned in black; scutellum yellow; halteres creamy-white. Legs with black coxae; femora smoky with streaks of black; tibiae and tarsi black. Wings hyaline. Abdomen blue-black on dorsum with

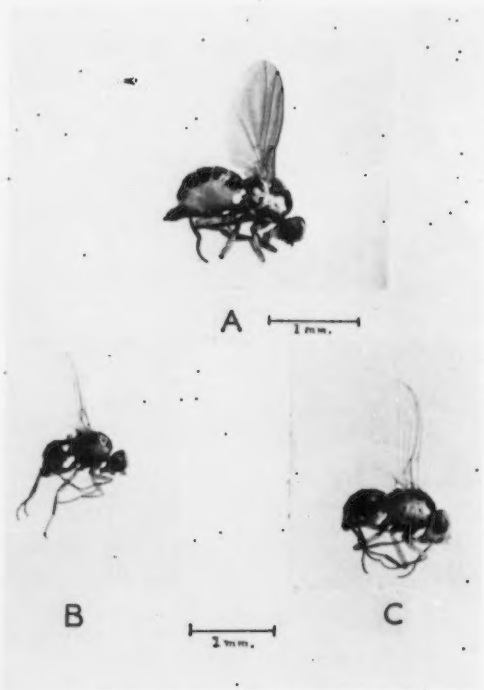

FIG. 2.—*Liriomyza pictella* (Thomson) Adults: (A) gravid female; (B) male; (C) female.

very narrow bands of yellow on posterior margins of the segments. Laterally, the abdomen of the female is translucent light-yellow, whereas that of the male is pale yellow.

SEASONAL POPULATION TRENDS

The seasonal field population trends of *L. pictella* were followed in the Patterson area of the San Joaquin Valley of California during 1954 and 1955. Surveys were conducted at 1- to 2-week intervals throughout the growing season.

The populations were detected early in the season by observing mining larvae in the coty-

ledons and the first true leaves of the melon plants. The population level was determined by taking random samples consisting of 20 to 50 leaves from the center of the plants, from each of the several fields under observation. The samples were placed in parasite emergence cages in the laboratory. After 1 month, the emerged adult melon leaf miners and parasites were recorded. In addition to the above survey method, random samples of 10 leaves were taken at 7- to 10-day intervals from different fields and from several varieties of melons, during July and August, and microscopically examined in the field for the presence of unparasitized and parasitized leaf miner larvae.

All available evidence indicated that the melon leaf miner overwinters in the pupal stage on or in the soil and under the debris of the host plant. Webster and Parks (1913) reported that a closely related species of *Liriomyza* hibernated in this manner. The adult probably begins to emerge around the first of April. Miners were detected in the Patterson area in the leaves of wild sunflower, volunteer alfalfa, and in the cotyledons of the earliest varieties of melon by the middle of April.

TABLE 2.—Average number of oviposition and feeding punctures produced by ten *Liriomyza pictella* females on bean plants at various intervals under greenhouse conditions.

Age in days	Number of Punctures			
	Egg		Feeding	Total
	Fertile	Non-fertile		
10	40 9	7 7	188 6	237 2
19	35 2	7 3	261 3	303 8
25	15 3	6 5	126 9	148 6
31	4 7	5 1	53 6	63 4
38	0 7	2 0	14 8	17 5

Populations of the leaf miner remained at a very low level through April and May, increasing to the point where they were readily observed in commercial alfalfa, bean, and melon fields by the first week in June. The insect continued to increase through June, and by early July large populations were present on most of the cultivated and wild hosts. The trend continued upward until a peak was reached around the middle of August.

The normal trend of the melon leaf miner population during the height of the growing season was somewhat obscured by the use of insecticides throughout the area.

The population varies considerably from host to host, field to field, and even within areas in the same field. The numbers of leaf miner within a field may suddenly reach highly destructive levels in one area, while remaining well below an economic population in others. Field observations indicated that the infestation is generally heaviest in the plants along the edge of the fields. This seems to be particularly true where fields are bordered with trees or buildings. The reasons for this are not known. However, it is possibly due to the fact that the adult leaf miner is reluctant to leave its immediate host. Within the field the adults can disperse in any direction, but at the edge of the field, because of their close relationship with the host, they have only a 180° range for dispersal.

The melon leaf miner often reaches destructive levels during July and August. When this occurs, severe economic losses may be incurred due primarily to the mining of the larvae, and secondarily, to the feeding and oviposition punctures of the females. Several important agricultural plants may be affected (figure 3).

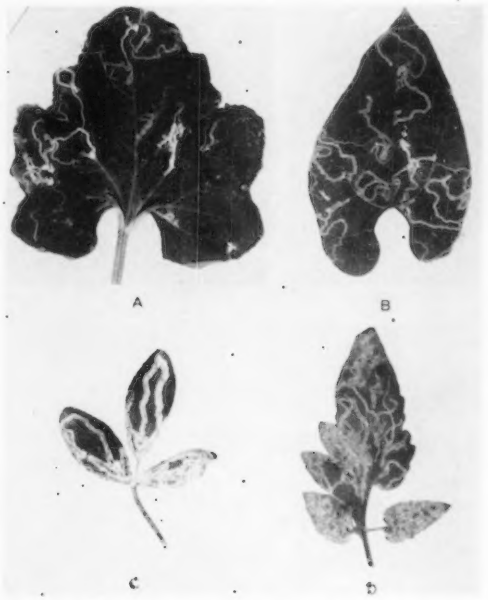

FIG. 3.—Leaves of host plants mined by the larvae of *Liriomyza pictella* (Thomson): (A) honeydew melon; (B) Henderson bush lima bean; (C) alfalfa; (D) tomato.

The population level steadily decreases from the middle of September. Several factors which bring this about are parasitism, harvesting, shorter days, and cooler temperatures. The latter two produce unfavorable conditions which cause a decline in vigor of host plants and are probably responsible for inducing the melon leaf miner to go into a winter diapause.

An extremely high percentage of the overwintering pupae are parasitized. The remainder suffer high mortality because of inclement winter weather and cultural practices such as plowing and cultivation.

LIFE HISTORY STUDIES UNDER GREENHOUSE CONDITIONS

Adult

Emergence.—The adults of *L. pictella* emerge from the puparia by breaking through the dorsal anterior end with the aid of the ptilinum. During this process the ptilinum is alternately inflated and deflated with air. When deflated, the air and body liquids are forced back into the abdomen, causing the posterior to push against the end and sides of the puparium. In this manner the head, followed by the thorax, is extended from the puparium. The front legs are withdrawn next, and, when freed, are used against the surface to aid in freeing the other pairs. At times the adult may have considerable difficulty freeing the long legs, and especially the last two pairs, from the inner membraneous sac. The entire process of emergence may require only 5 minutes, but may take an hour or more if difficulty is encountered. Some adults die before completing the emergence process.

When free from the puparium, the positively phototactic adults are active and crawl up the sides of the container towards the light. Here they remain quiescent as they expand their wings and bodies. The wings are usually fully expanded within 20 minutes and the body is fully sclerotized and colored after 1 hour. Females usually emerged from the larger puparia.

The adult melon leaf miner begins emerging from the puparium in the early daylight hours. Experiments involving 678 individuals revealed that the majority emerged before 9 a. m. and all but 11 emerged before noon. These emerged before 2 p. m. There was no evidence of emergence between 2 p. m. and 6 a. m. In another experiment, 198 emerging adults were checked every half hour. Emergence began as early as 6 to 6:30 a. m., gradually increased in numbers until 7:30 to 8:00 a. m. and decreased from then until noon. By noon 195 individuals had issued and the remaining three emerged by 1 p. m.

The sex of the adults was recorded as they emerged from puparia in various experiments. The results of 889 recorded observations including 433 males and 456 females revealed that the sex ratio of males to females, reared on bean, was 1.0:1.05. A similar ratio was obtained where flies were reared on alfalfa and lupine. There was apparently no differentiation between the sexes as to which emerged first.

Mating.—At various periods during the day the adults were observed for mating habits. These observations were made in the series of behavior studies that involved oviposition-longevity experiments.

During copulation, the male assumes a position from behind and astride the female's abdomen at approximately a 45° angle above her body. The first two pairs of the male's legs clasp the abdomen of the female, while the hind legs rest on the leaf. The female stands quietly with her wings slightly spread in a horizontal plane. The wings of the male are folded in the normal resting position, their tips touching the leaf. The male's abdomen is brought forward and downward to connect his copulatory organs with those of the female. This position is maintained throughout copulation.

Adults were seen mating within 6 hours after emergence, but usually mating did not occur until the following day. Pairs were often observed copulating as late as 15 to 20 days after emergence, and in one instance mating occurred after 30 days. Mating was observed to take place at various times between 9 a. m. and 5 p. m., but generally occurred during the morning hours. One pair of adults mated on 5 consecutive days, and another pair was observed mating on 4 separate occasions within the same day. Still another pair was observed in copulation 10 different times over a period of 21 days. Generally the adults were observed in copulation from 30 minutes to 1 hour, but on several occasions the period extended to 2½ and 3 hours. Females which were isolated for a period of 2 weeks were capable of producing fertile eggs within 12 to 24 hours after being exposed to males.

A replicated experiment was conducted in

TABLE 3.—Number of fertile eggs laid and longevity of female *Liriomyza pictella* (Thomson) when subjected to males for varying periods of time under greenhouse conditions.[a,b]

Number Females per Test	Time Assoc. with Male	Longevity in Days		Number Fertile Eggs	
		Range	Average	Range	Average
11	constant	35–53	42.3	130–1425	717.3
13	constant	23–57	38.2	227–1014	657.8
7	7 days	17–47	32.8	61– 588	336.8
8	2 days[c]	28–57	39.0	324– 886	497.3

[a]Plants changed daily.

[b]Temperature range 17.2°–36.7° C.; average 26.5° C.; relative humidity range 24%–57%; average 40.5%.

[c]Males removed after 2 days and then 14 to 24 days later each female given 3 males for period of 3 days.

which 6 males were placed with 20 females on a caged bean plant. After 1 week the females were removed and placed singly on fresh bean plants. When the plants were examined 3 days later for eggs and mining larvae it was found that 17 of the 20 females were laying fertile eggs. These results show that a male is capable of mating with and fertilizing several females.

Feeding and Oviposition.—The adults are closely dependent upon the host plant, particularly the female which makes the feeding and oviposition punctures. These are generally produced on the upper surface of the leaves. When ready to make a feeding puncture, the female selects a suitable spot and brings the end of her abdomen forward and downward until the end of the elongated posterior segment is touching the leaf. With several thrusting motions of her body, the ovipositor penetrates the leaf. Within the leaf this organ spreads out horizontally into a flat fan-like structure, which is thrust straight back, just beneath the leaf surface, with each twisting turn of the abdomen. The ovipositor is then quickly withdrawn. The feeding wound is semicircular and measures approximately 0.35 mm. in diameter.

The oviposition puncture is made in practically the same manner as the ones for feeding. Webster and Parks (1913) noted this in their study of a closely related species of *Liriomyza*. The female, after selecting a suitable area, stands for a moment making several forward and backward pumping motions, using her entire body. The ovipositor is then inserted in the leaf as described above, except that it is thrust straight backward only once, then withdrawn slightly and held in that position while again making several pumping motions with the abdomen. The egg is then quickly expelled and the ovipositor is withdrawn. The eggs are deposited just beneath the leaf surface, a third of their length from the puncture. Tilden (1950) reported similar observations in regard to the oviposition habits of *Liriomyza pusilla* (Meigen) on *Baccharis pilularis* DC. The leaf surface is slightly raised at the site of the egg and is faintly visible when examined with 9x magnification. The oblong oviposition puncture measures approximately 0.35 by 0.18 mm.

The female, after producing either a feeding or an oviposition puncture, quickly backs over the wound and feeds upon the exudation. Feeding punctures may be either scattered or concentrated in one general area, while the eggs are deposited more at random over the leaf.

The male feeds primarily upon natural exudations from the axils of the leaves, but will feed upon the wounds produced by the female's feeding and oviposition punctures. The female also feeds upon the natural plant exudations, but usually only during old age as most of her life is spent making feeding and oviposition punctures from which she obtains nourishment.

The feeding punctures appear to be most numerous along the tips and margins of the first true leaves but are also sparsely scattered over the surface of the later trifoliate leaves. Under high population pressures, the feeding punctures become very numerous on the younger trifoliate leaves, and more eggs are also laid there.

TABLE 4.—Longevity of adult *Liriomyza pictella* when kept together on bean plants under greenhouse conditions.*

Number per test		Longevity in Days			
		Male		Female	
Male	Female	Range	Average	Range	Average
8	10	13–39	30.1	31–53	42.0
17	17	25–45	35.9	25–55	43.8
12	12	22–33	27.3	35–53	45.7
14	17	20–32	26.8	23–57	39.1

*Temperature range 17.2°–39.4° C.; average 27.2° C.; relative humidity range 20%–65%; average 40.8%.

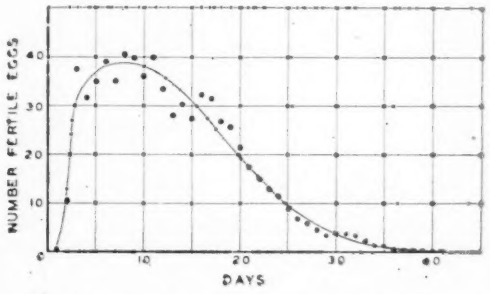

FIG. 4.—Average daily fertile egg deposition by 24 *Liriomyza pictella* females during their life span.

The numerous feeding punctures seriously affect the normal physiological activity of the plant and eventually kill the affected cells, which later give the appearance of white, necrotic depressions in the leaves (figure 3). Elmore and Ranney (1954) reported that feeding and egg punctures on seedling chili pepper plants in Southern California by a related species of *Liriomyza* caused severe stunting and killing of many plants.

The feeding and oviposition punctures were produced almost entirely during the daylight hours. This was established through several experiments, each replicated six times. The data showed that practically all of the feeding and oviposition punctures were produced between 7 a. m. and 7 p. m. Almost twice as many fertile eggs were laid between 7 a. m. and 1 p. m. than there were between 1 and 7 p. m. The number of feeding punctures produced was approximately the same in the morning as in the afternoon hours.

An experiment was conducted in which the total number of both fertile and non-fertile egg punctures and feeding punctures were recorded

at intervals throughout several oviposition and longevity studies. The bean plants were replaced daily to provide sufficient space for feeding and oviposition punctures and to prevent competition between the mining larvae. The results, shown in table 2, indicate that the female starts producing large numbers of feeding punctures and fertile egg punctures within a very short time after emerging and mating. The average ratio of feeding punctures to oviposition punctures was approximately 5:1. The ratio was about 4:1 after 10 days, increased to 6:1 at 19 and 25 days, then decreased to 5:1 at the end of the female's life. The number of feeding punctures steadily increased up to the third week, then gradually decreased, and the number of fertile eggs steadily decreased after the first 7 to 10 days. The ratio of fertile eggs to non-fertile eggs laid was 5:1 at 10 and 19 days and then steadily decreased to a ratio of 1:3 towards the end of the female's life span. Wolfenbarger (1947), in his studies of closely related species of *Liriomyza* in Florida, noted that less than one percent of the oviposition punctures contained eggs.

TABLE 5.—Size of mouth hooks of the different instar larvae of *Liriomyza pictella* (Thomson).[a]

Instar	Length in Millimeters		
	Minimum	Maximum	Average
First	0.07	0.10	0.09
Second	0.13	0.17	0.15
Third	0.22	0.26	0.23

[a]Mouth hooks of 25 individuals of each larval instar measured along longitudinal axis.

Females paired with males at emergence, mated, and were laying fertile eggs within 48 hours. In a few instances fertile eggs were laid within 24 hours. Figure 4 shows the average number of fertile eggs laid daily by 24 fertilized females which were in constant association with the males on bean plants changed daily. The average daily fertile egg deposition rose quickly to a peak production of 35 to 40 eggs, remained there for 6 to 10 days, slowly but steadily declined to an average of 3 to 5 eggs daily at 30 days, only 1 per day at 40 days, and none at 42 days. Twenty-one of the 24 females were still laying fertile eggs 3 weeks after emergence, ten were ovipositing after 4 weeks, five at 5 weeks, and one after 41 days.

Non-fertilized females laid hundreds of unfertilized eggs in the leaf tissue of the bean plants in the usual manner. The development of the ovaries, egg laying, and other responses appeared to be the same as those of fertilized females. In some cases mated females did not lay fertile eggs. A few did not produce either feeding or oviposition punctures and fed only upon natural plant exudations.

Oviposition studies were conducted simultaneously with the longevity experiments. The experimental design is explained in the following section on longevity. In replicated experiments using fertilized females which were in constant association with males, and where the host plant was changed daily, the females laid an average of 717 and 658 fertile eggs in successive experiments (table 3). This was twice as many eggs as were laid by females which were permitted to be with the male for the first week only. The largest number of fertile eggs laid by a single female in constant association with males was 1425 and the smallest 130. Where the males were removed after one week, the largest number produced by a female was 588 eggs and the smallest 61.

Table 3 also gives the results of an experiment in which the males were removed from the females after 48 hours of association and newly emerged males re-introduced 2 to 3 weeks later for a period of 3 days. Fifty percent of the females, after almost or entirely ceasing egg production, began ovipositing fertile eggs again. This procedure raised the average number of eggs per female to 497 compared to an average of 337 eggs where the males were permanently removed after 1 week's contact with the females. This suggests that repeated mating is necessary for maximum fertile egg production.

Longevity.—A series of experiments were designed to determine the life span of the adults under various conditions. Bean plants were utilized as hosts and were replaced by fresh plants to maintain an adequate feeding source. Plants used in tests involving unfertilized females were changed weekly, but were changed daily when fertilized females were studied. The cages were checked daily for dead adults.

Several experiments were conducted during different periods of the year in which paired adults were placed in oviposition-longevity cages immediately after emergence. In four of these studies the males and females were in constant association until their death. In a fifth, the males were removed after 48 hours of association with the females, then 2 to 3 weeks later new males were added for a 3-day period. The results obtained are given in tables 3 and 4. It may be concluded from these data that the females' average life span was 10 to 12 days longer than that of the males. There was some indication that females lived longest when they were in constant association with males. The life span of the females ranged from 17 to 57 days, with an average of 42.6 days, and that for the males ranged from 13 to 45 days, with an average of 30 days.

Newly emerged adults were maintained in separate longevity cages according to sex. A total of 21 males and 19 females was used. Under these conditions the life span of the unmated female averaged 36.5 days, or 8 days

longer than that of the males. The life span of these females averaged 6 days less than that of fertilized females in constant association with males. The male life span was not changed.

Aged females spent more time on the lower surfaces of the leaves, produced few feeding punctures, and apparently were more dependent upon plant exudations for food. They were sometimes found hanging by their ovipositors from the lower surface of a leaf. Usually, just before death, the adults were found at the base of the host plant where they exhibited weak and erratic movements when disturbed. They usually died within 24 hours.

Larva

Mining.—The first instar larvae emerge from the eggs and immediately begin to mine the leaves. Normally the larval period is spent in the palisade layers of the leaf. A typical serpentine mine is formed (figure 3). The mine increases gradually from an average width of 0.25 mm., at the point of emergence, to 1.50 mm. at the time the larva reaches full maturity. The mine appears greenish-white at first and later changes to white. A line of dark green-black fecal matter is deposited in the mine as the larva feeds and progresses through the leaf tissue.

A series of larvae were examined microscopically to determine the average size of the mouth hooks. The data obtained show that there are distinct sizes for each larval instar (table 5 and figure 2).

The larvae mine and complete their development upon many species of plants. They mine the tissue between the two surfaces, including the veins and petiole when under high population pressures. The older larvae are readily observed feeding just beneath the leaf surface, slashing through the mesophyll cells with a lateral semicircular motion of their mouth hooks.

There are three molts and three larval instars. Two of the molts occur in the mine, the third when the puparium is formed. The only remaining evidence of the first two molts is the presence of the molted black sclerotized mouth hooks within the mine. The mouth hooks of the mature third-instar larva are left within the ventral anterior end of the puparium.

Larval movement within the mines is of a peristaltic type. As the larvae increase in size, their dorsal and ventral sides contact the top and bottom of the mines, aiding them in their movements. In a heavily mined leaf, the larvae often have to move some distance to find green leaf tissue. This was particularly true of the third-instar larvae. In doing so they progress in the manner described, quickly eating any green tissue encountered.

Emergence.—The mature larvae, when ready to pupate, cut a semi-circular slit in the top of the mine, either at or near the end. This opening was, with few exceptions, on the upper surface of the leaf. They emerged with their characteristic expansion-retraction peristaltic-type motion. When the larva is three-fourths out of its mine, its head is moving about high above the leaf surface. It literally falls out of the mine at this point and immediately begins to move toward a suitable pupation site. Movement outside of the mine is essentially the same as within, except for an additional rolling motion which accompanies the typical forward movement previously described. This usually causes the larva to fall from the leaf to the ground. Here it normally tends to bury itself a few centimeters into the loose soil. If this is not possible, it attempts to crawl beneath some object to pupate. Occasionally a few pupae may be found pupating on the surface of the leaves or at the base of a leaf or attached to the leaf, stem, or stalk of the plant. This manner of emergence and pupation

TABLE 6.—Time of emergence of mature larvae of *Liriomyza pictella* (Thomson) from bean leaves under greenhouse conditions.*

Number of Larvae per Test	Number Emerging Between Indicated Hours										
	a.m.								p.m.		
	5	6	7	8	9	10	11	12	2	4	6
78	–	—	23	12	12	10	10	4	4	3	0
42	–	—	—	31	7	3	1	0	0	0	0
74	–	—	33	10	14	6	2	3	6	0	0
138	–	—	92	15	20	5	3	2	1	0	0
20	–	—	0	11	4	1	2	2	0	0	0
145	–	—	75	61	2	3	2	2	0	0	0
153	–	65	27	25	5	12	8	4	4	2	1
85	–	—	9	14	28	20	11	3	0	0	0
Totals 735	–	65	259	179	92	60	39	20	15[b]	5	1

*Temperature range 21.7°–32.8° C.; average 27.2° C.; relative humidity range 32%–42%; average 37.2%.

[b]Nine of the fifteen had emerged by 1 p.m.

was also noted by Tilden (1950) in his studies of *L. pusilla*.

Emergence of the larvae and pupation occurs almost entirely during the early daylight hours. To establish the time of emergence of the mature larvae, large numbers were checked hourly between 5 a. m. and 6 p. m. over a period of several days. The data (table 6) show that 714 larvae out of a total of 735, emerged between 5 a. m. and noon, the largest number emerging between 6 and 7 a. m. Fifteen of the twenty-one larvae which emerged in the afternoon emerged before 2 p. m.

TABLE 7.—Duration and percent mortality of pupal stage of *Liriomyza pictella* (Thomson) under greenhouse conditions.*

Number of Pupating Larvae	Duration of Pupal Stages (days)		Percent Mortality
	Range	Average	
76	9–11	9.8	23.7
50	8–11	9.6	26.0
45	7–10	8.9	—
40	9–11	10.0	42.5
25	9–11	10.2	20.0
50	8–10	8.6	40.0
30	8–9	8.2	30.0
50	7–8	7.8	32.0
40	8–9	8.4	25.0

*Temperature range 16.7°–37.8° C.; average 27.3° C.; relative humidity range 22%–61%; average 38.6%.

Pupation.—The larva, when ready to pupate, secures its posterior end to the substrate and begins a series of undulating motions, elevating the anterior end. This motion gradually becomes less intense. Meanwhile the dark-green contents of the intestine are ejected, which aids in fastening its posterior to the surface. As the body becomes shorter and thicker, it slowly falls forward to the characteristic pupal resting position. This entire process requires an average of 20 to 30 minutes.

Experiments were conducted at various times throughout the year to determine the length of the pupal period. A total of 406 mature third-instar larvae was placed singly into ventilated vials and observed for adult emergence. Under greenhouse conditions averaging 27.3° C. and 38.6% R.H., the pupal period ranged from 7 to 11 days, with an average of 9 days (table 7). Mortality of the pupae under the conditions of the experiment ranged from 25% to 42.5% with an average of 29.9%. This was almost twice as high as the mortality rate obtained in later experiments conducted under more favorable conditions for pupation.

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THE MORPHOLOGY AND SYSTEMATICS OF THE PIESMATIDAE (HEMIPTERA), WITH KEYS TO WORLD GENERA AND AMERICAN SPECIES[1]

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ABSTRACT

The Piesmatidae seem most nearly related to Lygaeidae of the tribe Cymini. External morphology, and the anatomy of the male and female reproductive organs, are described and figured. In *Piesma* 7 American species are treated here, 3 species and 3 varieties being reduced to new synonymy; and an alphabetical list is given of the 24 species known from the Old World. *Miespa* Drake, with 1 Chilean species, and *Mcateella* Drake, with 4 species in Australia, are the other genera of the family. A brief account is also given of the role played by two *Piesma* species in transmitting virus diseases of plants, *P. cinereum* being a biological carrier of savoy disease of sugar beets in North America, and *P. quadratum* a vector of leaf-crinkle in Central Europe.

The family Piesmatidae constitutes a rather small group of plant-feeding bugs inhabiting the temperate and tropical regions of both the Old and New Worlds. Up to the present writing, no member of the family has been recorded from any oceanic island, or even from Madagascar, the East Indies, or the West Indies. Of the 3 genera and 36 species now described, 2 genera and 8 species are recognized herein from the Americas and 2 genera and 28 species are recorded from the Eastern Hemisphere. *Piesma* Lepeletier and Serville is the most widely dispersed genus and the richest in species. It is represented on all of the continents except Australia, but none of its species is known to inhabit both the Eastern and the Western Hemispheres. The other genera, *Miespa* Drake and *Mcateella* Drake, are listed only from Chile and Australia, respectively.

The first piesmatid from the Americas was described as *Tingis cinerea* by Thomas Say (1832: 27), who simply stated, "Inhabits United States"; it was transferred to the genus *Piesma* by Stål (1873: 116). More than a half-century after Say, Uhler (1895: 56) characterized the second American member of the family as *Agrammodes costatus*, new genus and new species, from Colorado. Van Duzee (1917: 223) not only failed to recognize *costatum* as a brachypterous form of *Piesma*, but also wrongly transferred *Agrammodes* to the tingid tribe Serenthiini Stål (now subfamily Agrammatinae).

In his taxonomic treatise on piesmatids, McAtee (1919) discussed the family characters and relationships, recognized dimorphism of wings, described eight new species and one variety, and suppressed the genus *Agrammodes* as representing merely the brachypterous form of a valid species of *Piesma*. We are relegating three of the new species characterized by McAtee into synonymy. The genus *Miespa* Drake (1948: 73) was erected for the reception of *Mcateella reedi* Drake (1939: 331) from Chile.

Since McAtee published on the Nearactic piesmatids nearly 40 years ago, no other paper has been written on the American species. The present treatise is largely systematic and morphologic in nature, and no new species are described. Comments are also included upon two members of the genus *Piesma*, one American and the other European, which are biologic carriers and vectors of serious virus diseases of sugar beets and related crops.

As the gender of the name of the type genus *Piesma* is neuter (Greek *piesma*, a pinching or squeezing, genitive *piesmatos*, stem *piesmat-*), the spelling of the family name should be Piesmatidae rather than Piesmidae; and the endings of specific names must likewise be neuter. We are, of course, mindful that Stichel (1926: 102), Hacker (1927: 30), Hoberlandt (1942: 123), Grensted (1954: 71), and others have previously written the family name as Piesmatidae.

MORPHOLOGY

Heretofore the most complete description of the morphology of piesmatids was that of Wille (1929), who studied *Piesma quadrata* (Fieber). In addition, details of the stridulatory apparatus have been noted by Schneider (1928), Mayer (1940), and most recently by Leston (1957). The metathoracic scent glands have been studied by Brindley (1934), and Pendergrast (1957) has described the spermatheca. The male genitalia were studied by Singh Pruthi (1925) and by Pendergast (1957).

Head.—The head of piesmatids is rather broad and short and is inserted into the prothroax up to the eyes (figs. 1–4). It is porrect in *Piesma* (fig. 1), but is moderately declivent in *Miespa* and *Mcateella*. (fig. 2). The eyes are strongly convex. Ocelli are present and widely separated in macropterous forms (fig. 3), but poorly developed or absent in brachypterous individuals. The juga are distinctly produced, being subequal to the tylus in *Mcateella* (fig. 3) and *Miespa* (fig. 4), and usually greatly surpassing it in *Piesma*

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(fig. 1). The bucculae are long, fairly wide, areolate, and parallel (fig. 1). The labial channel formed by them is open anteriorly (fig. 4).

The antennae are four-segmented and moderately long (fig. 3). The first segment is short and thick, the second long and subcylindrical, the third thin, cylindrical, widening slightly apically, and usually longer than the other segments. The last segment is fusiform. The antennae are inserted on the sides of the head, slightly below the midline of the eye. Between the eye and antennal socket there is a prominent antennal tubercle. In *Miespa* and *Mcateella* this tubercle is simple (fig. 2) but it is generally bifid in *Piesma* (fig. 1).

The labium is four-segmented and moderately long (fig. 1). The first and last segments are longest and the third is moderately swollen.

Thorax.—The pronotum is transversely subrectangular; along its lateral margins there are laminate extensions termed *paranota* (fig. 28). The disc is convexly elevated posteriorly and is usually bi-or tricarinate. Calli are present, but a pronotal collar is lacking. The scutellum is moderately small and exposed.

On the ventrolateral surface of the thorax distinct propleural and mesopleural sutures may be distinguished (fig. 4). On the dorsal end of the propleural suture there is an invagination of the body wall forming a distinctive feature of piesmatids and designated herein as the *propleural cavity* (fig. 4, PpC). At its base this cavity is fused to the inner surface of the pronotum and appears to form a supporting structure for the origin of the prothoracic leg muscles. This structure is peculiar to and known only in Piesmatidae.

The procoxal cavities are open (fig. 4). A shallow labial channel extends posteriorly between the coxal cavities. In *Piesma* and *Mcateella* there are distinct ridges along the channel on the anterior part of the pro- and the mesothorax. In *Miespa* these ridges are present only on the prothorax.

On the mesopleuron of *Piesma* and *Mcateella* there is a process or tubercle at the dorsal end of the metapleural suture. In *Piesma* it is usually small and somewhat variable in size. In *Mcateella* the mesopleural process is quite prominent and always bifid (fig. 4). This process is not present in *Miespa*.

The pronotum and most of the pleural regions are coarsely punctate. Midventrally and on the anterior lateral surfaces of the mesopleuron where the flight muscles are attached, the surface is finely granular.

Legs.—The legs lack spines and teeth. The femora are never swollen and the coxa are of the rotatory type. The tarsi are two-segmented and pseudarolia are present.

Hemelytra.—In *Piesma* both macropterous and brachypterous forms are common while brachypterey is unknown in *Mcateella* and *Miespa*. Regardless of their forms, the hemelytra completely cover the abdomen. The leading edge of the hemelytron extends downward forming a border, the *infracostal* or *hypohemelytral lamina*, which curves under the edge of the connexivum. In the macropterous form the *clavus* (Cl) and claval suture are distinct and a claval commissure is present (fig. 7). The corium usually consists of several regions which are customarily referred to as the *costal area* (fig. 7, CA), the *subcostal area* (ScA), the *cubital area* (CuA), and the *brachial area* (BrA). The coreation of the hemelytron extends down into the basal portion of the membrane forming a region known as the *sutural area* (SA). The sutural area of *Miespa* is broader than that of *Piesma* and in *Mcateella* it replaces all of the membrane but a narrow strip along the anal margin (fig. 11). All of the coriaceous portion of the hemelytron of piesmatids is covered with many broad pits, or areolae, which give the wing a finely reticular appearance. In *Piesma* and *Miespa* four longitudinal veins extend through the membrane, but the membrane is without closed cells (fig. 7).

In the brachypterous form the various areas of the corium described above are present, and even more distinct. The claval suture is absent and there is an additional region, the *interstitial area*, between the clavus and the brachial area (fig. 12, IsA). The membrane is lacking and is largely replaced by the sutural area. The hemelytra in these forms do not overlap, but only meet along a midline for almost their entire length.

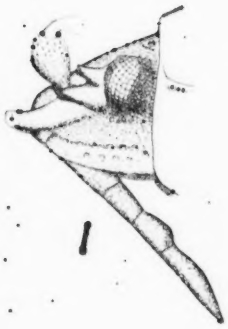
EXPLANATION OF PLATE

Abbreviations

BP, basal plate; BrA, brachial area; CA, costal area; CjA, conjunctival appendage; Cl, clavus; Cnj, conjunctiva; CnxM, connexival membrane; Cu, cubitus; CuA, cubital area; EjR, ejaculatory reservoir; Gap, gonapophysis; Gop, gonocoxopodite; H, hamus; IsA, Interstitial area; IV, intervanal vein; Ju, jugum; Li, lima; M, media; Mb, membrane of hemelytra; Pg, pygophore; Pm, paramere; PpC, propleural cavity; Ps, phallosoma; Pt, paratergite; R, radius; S, sternum; Sa, sutural area; ScA, subcostal area; Sg, scent gland scar; Sp, spiracle; Sptc, spermathecal chamber; SptD, spermathecal duct; SptG, spermathecal gland; T, tergum; Tr, trichobothria; V, vannal vein; VF, vannal fold; Vs, vesica.

Plate I

Fig. 1.—Head of *Piesma cinereum*.
Fig. 2-3. Head of *Miespa reedi*.
Fig. 4.—Venter of head and thorax of *Mcateella splendida* with beak and legs removed.
Fig. 5.—Hind wing of *M. splendida*.
Fig. 6.—Hind wing of *M. reedi*.
Fig. 7.—Hemelytron of *P. cinereum*.
Fig. 8.—Venter of abdomen of *P. cinereum*.
Fig. 9.—Hind wing of *P. cinereum* male.
Fig. 10.—Dorsum of terminal abdominal segments of *P. cinereum*.
Fig. 11.—Hemelytron of *M. splendida*.
Fig. 12.—Brachypterous hemelytron of *P. proteum*.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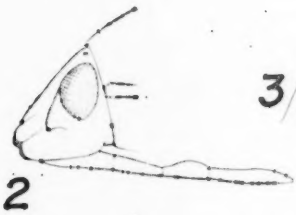
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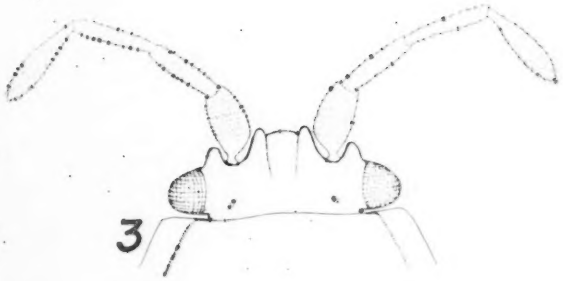
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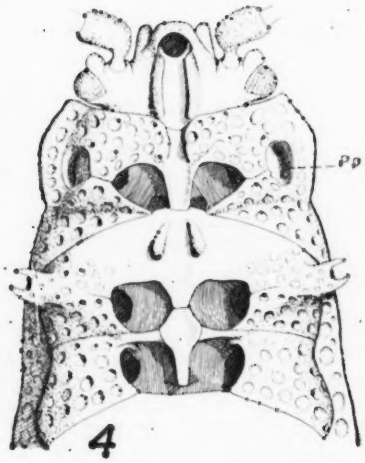
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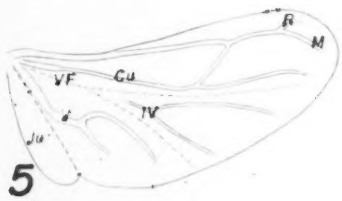
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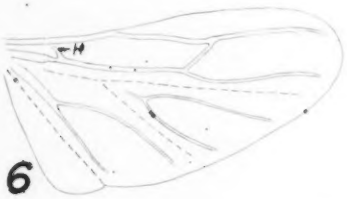
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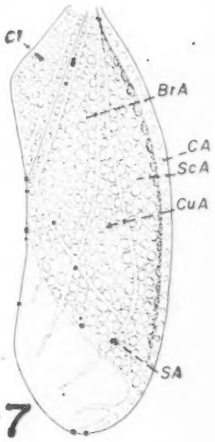
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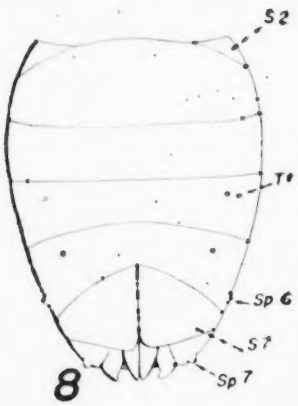
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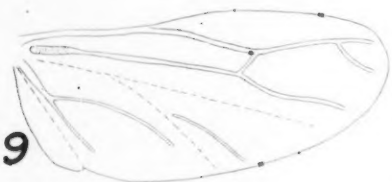
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T9
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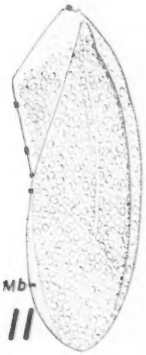
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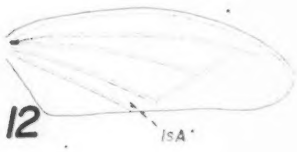
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Hind wings.—The terminology used here for the venation of the hind wings follows that elaborated by Leston (1953). The subcosta (Sc) is absent, and the radius (R) and media (M) usually divide distally (figs. 5, 6, 9). The hamus is present in *Miespa* (fig. 6, H), but absent in *Mcateella* (fig. 5) and many species of *Piesma*. The cubitus (Cu) is distinctly thickened at its base in males, forming part of the stridulatory apparatus (see below). The so-called vannal fold (VF) is forked. Between its anterior and posterior branches there is a Y-shaped intervannal vein in *Mcateella* and *Miespa* (figs. 5, 6, IV), but usually only a single, straight vein in *Piesma* (fig. 9). The vannal area is broad. At their bases the vannal veins are fused and heavily sclerotized, but distally they are separate and markedly divergent (fig. 5, V). The so-called jugal lobe is rather small and without distinctive features.

Pregenital Abdominal Segments.—As in other Heteroptera only the tergal portion of the first segment may be distinguished (fig. 17, T1). In the male the first tergite is especially modified to function as part of the stridulatory apparatus (fig. 14) and will be discussed below. In both sexes the first and second median tergites are fused but the intersegmental membrane is present between the second and third median tergites (fig. 17). The remainder of the pregenital tergites are fused. Scent gland scars (SG) are present on the posterior margin of the third and fourth tergites only.

In *Miespa* the venter of the second segment is distinguishable but rather narrow (fig. 16, S2). In *Piesma* and *Mcateella* this portion of the segment is modified to form a rather broad membrane between the thorax and abdomen and only small ventrolateral sclerites remain (fig. 8, S2). The venter of the third and fourth segments is fused but a slight intersegmental membrane is present between the remaining pregenital segments, making it possible for the tip of the abdomen to be curved down slightly.

The connexivum is distinct dorsally (fig. 17) but the ventral connexival suture is absent (fig. 16). The dorsal connexival sclerites are joined to the median tergites by a broad convoluted membrane (fig. 15, CnxM). This membrane allows for considerable dorsoventral expansion of the abdomen thus taking the place of the greatly reduced intersegmental membranes (see Davis, 1957).

The first and eighth pairs of spiracles are absent. In *Mcateella* and *Miespa* the second through sixth spiracles are located in the dorsal connexival plates (fig. 17). The seventh spiracles are located in the posterior lateral margins of the connexiva. In *Piesma* the second through fifth spiracles are similarly located in the dorsal connexival plates and the sixth and seventh are on tubercles sublateral to the connexivum (figs. 8, 10).

In *Piesma* a single pair of trichobothria are present ventrolaterally on the fifth and sixth segments (fig. 8, Tr). The trichobothria appear to be lacking in the other genera.

Female Genitalia and Genital Segments.—The seventh segment is completely cleft midventrally. Posteriorly it overlaps the eighth segment (figs. 8, 27, S7) and in *Miespa* extends to the end of the abdomen (fig. 16, S7). The venter of the ninth segment (paratergites) is likewise cleft (figs. 15, 27T, PT 9), and, along with the venter of the seventh, completely encloses the ovipositor. When the ovipositor is extended, its base passes posteroventrally through the seventh segment and assumes the position shown in figure 15. In this position various elements of the female genitalia may be distinguished. The base of the ovipositor is formed by the large first gonocoxopodites (valvifers) (fig. 15, Gcp1) to which the first gonapophyses (valvulae) (Gap 1) are attached by short outer rami. Inner rami extend from the first gonapophyses to the ninth paratergites. The second gonapophyses (Gap 2), or those of the ninth segment, are united to the first by the usual tongue-in-groove mechanism and are joined together dorsally for most of their length. They are attached to the gonocoxopodites of the ninth segment by rami. These gonocoxopodites are greatly reduced and concealed beneath the ninth paratergites.

The ninth median tergite is distinguishable in *Mcateella* (fig. 26, T9) but is apparently reduced to two lateral lobes in *Piesma* (fig. 10, T9) and is concealed beneath the eighth tergum in *Miespa* (fig. 17). The tenth segment is apparently a small annular sclerite, mostly concealed in *Mcateella* and *Miespa* but indistinguishable in *Piesma*.

Internally at the base of the ovipositor there is a small genital chamber. Extending dorsally

EXPLANATION OF PLATE

PLATE II

FIG. 13. Phallus of *Piesma cinereum*.

FIG. 14.—Dorsum of anterior abdomen of male *P. cinereum* showing modifications for stridulation.

FIG. 15.—Dorsolateral view of terminal segments of abdomen of female of *P. cinereum* showing ovipositor extended.

FIG. 16.—Venter of abdomen of *Miespa reedi*.

FIG. 17.—Dorsum of abdomen of *M. reedi*.

FIG. 18.—Dorsal aspect of right paramere of *M. reedi*.

FIG. 19.—Phallus of *M. reedi*.

FIG. 20.—Phallus of *Mcateella splendida*.

FIG. 21.—Spermatheca of *P. cinereum*.

FIG. 22.—Spermatheca of *M. reedi*.

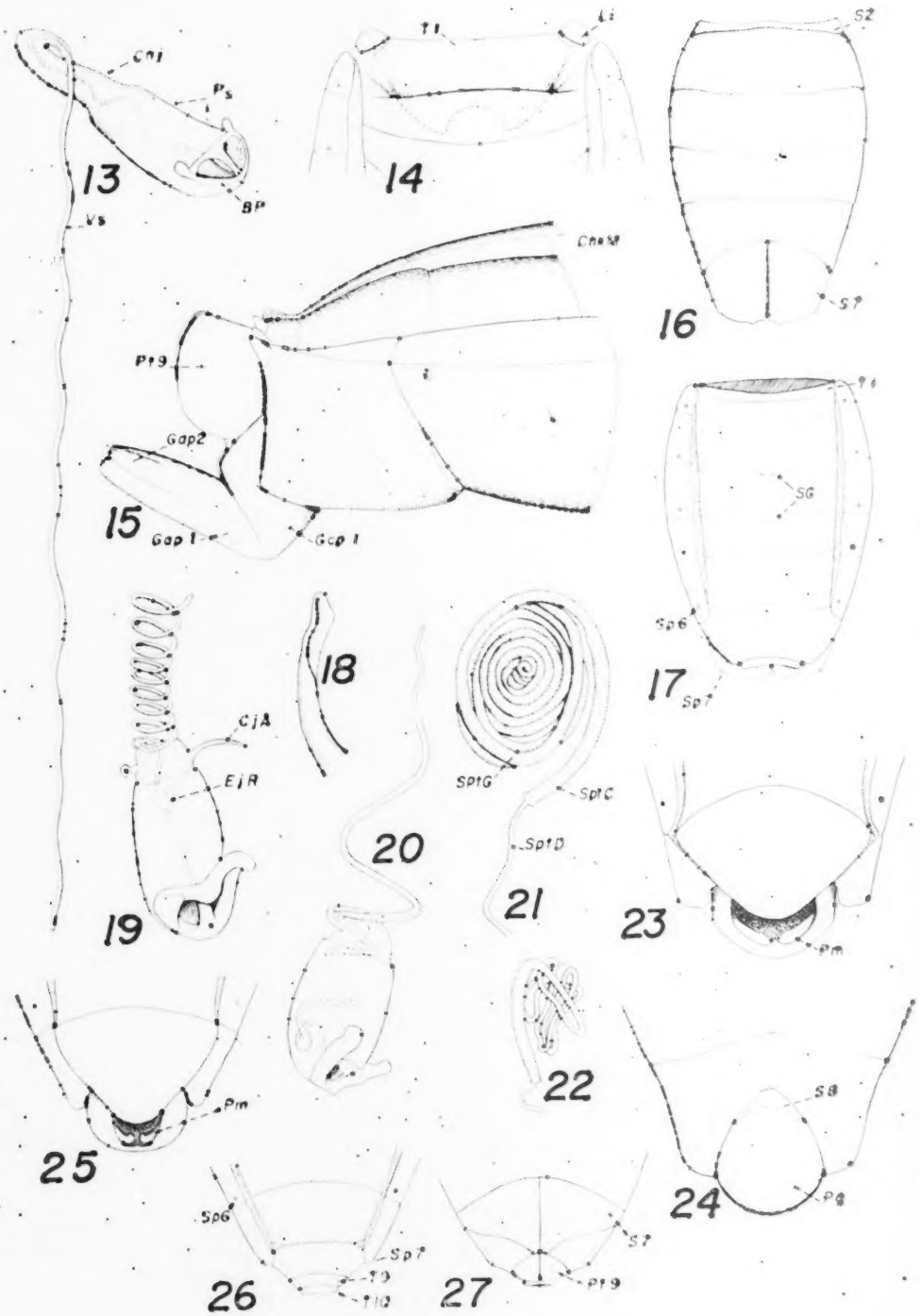
FIG. 23.—Dorsal aspect of terminal abdominal segments of male of *M. reedi*.

FIG. 24.—Ventral aspect of terminal abdominal segments of male of *M. reedi*.

FIG. 25.—Dorsal aspect of terminal abdominal segments of male of *M. splendida*.

FIG. 26.—Dorsal aspect of terminal abdominal segments of female of *M. splendida*.

FIG. 27.—Ventral aspect of terminal abdominal segments of female of *M. splendida*.


Cpl
Ps
13
BP
Vs
T1
L1
14
S2
16
S?
Cho M
Pt 9
Gap2
15
Gap 1
Gcp 1
T1
SG
Sp6
17
Sp?
18
CjA
EjR
19
SptG
SptC
SptD
20
21
23
Pm
22
25
Pm
S8
24
P8
Sp6
Sp?
T9
T10
26
S?
Pt 9
27

from its roof is a long tubular spermatheca (fig. 21). This organ consists of a basal (SptD) and a very long tubular apical gland (SptG). There are annular folds in the wall of the spermathecal chamber and it has an outer muscularis. The terminal gland is arranged in a flat spiral in *Piesma*, there being about four whorles in *P. quadratum* but many more in *P. cinereum* (fig. 21). In *Mcateella* and *Miespa* the terminal gland is arranged in a series of loops rather than a spiral (fig. 22).

Male Genital Segments and Genitalia.—The eighth segment of the male is annuliform, and at rest it and the ninth segment (pygophore) are drawn into the seventh segment (fig. 24, S8, Pg). In this position the eighth segment is completely concealed in *Piesma* and *Mcateella*, but a ventral portion of it is exposed in *Miespa*. Dorsally, the median tergite of the seventh segment extends posteriorly to cover partly the top of the pygophore (figs. 23, 25). The pygophore is of a bulbous shape characteristic of many Heteroptera. On its dorsal surface it bears the proctiger which is entirely membranous and gives no indication of its segmental compostion. A narrow sclerotized bridge arches over the anterior dorsal surface of the pygophore. The posterior rim of the pygophore is horizontal and bears a slight, anteriorly directed tooth.

At rest the parameres lie folded beneath the posterior margin of the pygophore (fig. 25, Pm). Their apices do not quite meet. The parameres are symmetrical and of a very simple form. They are evenly curved, lack processes, and terminate in a slight knob in *Piesma* and *Mcateella* (fig. 25) but are flattened apically in *Miespa* (fig. 18).

Within the pygophore lies the phallus. It is symmetrical and at its base is a stirrup-shaped sclerite typical of heteropterans and known as the basal plate (fig. 13, BP). There is a median extension from the bridge of the basal plate to the ventral edge of the basal plate. The ejaculatory duct passes through this median extension. The remainder of the phallus (fig. 13) is differentiated into phallosoma (Ps), conjunctiva (Cj), and vesica (Vs). The phallosoma is a simple, slightly sclerotized tube which encloses the conjunctiva and part of the vesica when the phallus is in repose. The conjunctiva is reduced and simple and bears no processes in *Piesma* and *Mcateella*. In *Miespa* there is a pair of long, symetrical, conjunctival appendages (fig. 19, CJA). The vesica is a very long, narrow, sclerotized tube. In repose the vesica is tightly coiled and lies at the distal end of the phallosoma. When the phallus is dissected out and placed in water the vesica frequently uncoils as shown in figure 13. If the phallus is then placed in glycerine the vesica will often coil up again. This behavior of the vesica may provide a key to understanding the mechanism of copulation of many Heteroptera with a highly coiled vesica. It seems quite possible that the vesica uncoils in a similar manner as it enters the genital chamber and spermatheca. The uncoiling would have a net effect of pushing the apex of the vesica forward through the spermatheca.

Within the phallosoma a small sclerotized thickening in the seminal duct may be seen. This is the ejaculatory reservoir (fig. 19, EJR).

Stridulatory Apparatus.—In males the base of the cubital vein is thickened and on its undersurface bears a number of fine transverse striae (fig. 9). In repose this portion of the wing lies immediately above a convex, ovate sclerite probably derived from the first abdominal tergum (fig. 14, Li). This sclerite has been termed the *lima* by Leston (1957). The body wall between the first and second median tergites extends inward forming a large phragma on which thick longitudinal muscles are inserted. Apparently the action of these muscles moves the fused first and second tergites back and forth, drawing limae across the striated surface of the cubital vein to produce sound.

FAMILY RELATIONSHIPS

There has, in the past, been considerable uncertainty as to the phylogenetic position of the family Piesmatidae. The piesmatids have, for example, been placed as a subfamily of Lygaeidae by various authors (see Flor, 1860) and as a subfamily of Tingidae by others. Reuter (1912) considered them to be a distinct family but included them in the superfamily Tingoidea. Their supposed relationship to the tingids has been based primarily on the two families possessing in common two-segmented tarsi, well developed bucculae, and a reticular body surface.

These characters are all ones that could easily be convergent and in recent years it has become well established that the Tingidae and Piesmatidae are not so closely related. The tingids all lack ventral trichobothria, have paired pseudospermathecae, have an undifferentiated endophallus, and in the hind wing have a distinct subcostal vein and distally fused radius and media. In contrast some piesmatids (*Piesma*) have ventral trichobothria, and all have a true spermatheca, an endophallus differentiated into conjunctiva and vesica, and the hind wing lacks a subcostal vein and the radius and media are separated distally. These various characteristics clearly relate the tingids to the Cimicomorpha and the piesmatids to the Pentatamorpha (see Leston *et. al.*, 1954).

Of the families comprising the Pentatamorpha the *Piesmatidae* appear to be most related to the Lygaeidae and Berytidae. These three families have in common four-segmented antennae and labium, paired ocelli, and four or five simple veins in the hemelytral membrane.

In addition to these characters, they have similar connexiva, a similar pattern of fusion of

abdominal segments, and a similar arrangement of abdominal spiracles. The piesmatids, however, are distinct from the other two families since they have two rather than three tarsal segments and have propleural cavities, a feature that sets them apart at once from all other families of Hemiptera.

The piesmatids appear to be most closely related to the Cymini of Lygaeidae. Like the Piesmatidae, the Cymini have the front femora unarmed and not swollen, the hemelytra punctate, the infracostal lamina well developed and enclosing the connexivum, the fore-coxal cavities open, and the nymphal scent glands in the same positions. In addition to the family differences, the piesmatids differ from cymines in their more pronounced juga, buculae, and in the form of the spermatheca. The phallus of piesmatids appears to be most like that of Blissinae (see Ashlock, 1957).

Family Piesmatidae Spinola 1850

Piesmides Amyot and Serville 1843: 300 (vernacular name).
Piesmoeideae Spinola 1850: 44 (as subfamily of Aradites).
Zosmenidae Dohrn 1859: 41 (as family).
Zosmeridae Douglas and Scott 1865: 237 (family name; as *Zosmoridae*, p. 22).
Piesmina Stål 1873: 115 (as subfamily of Tingitidae); Oshanin 1908: 395.
Piesmini Puton 1879b: 84; Puton 1886: 31; Puton 1899: 38 (as tribe of Tingitides).
Piesmidae Lethierry and Severin 1896: 1 (as subfamily).
Piesminae Champion 1879: 2 (as subfamily); Horváth 1906: 2; Van Duzee 1917: 210.
Piesmidae Horváth 1911: 14 (as family); China and Miller 1955: 260.
Piesmatidae Stichel 1926: 102; Hoberlandt 1942: 124.

Body surfaces densely punctate or areolate. Head porrect or slightly deflexed; juga produced, with apex subequal to or exceeding tylus; buculae long and moderately elevated; labial channel open anteriorly and extending onto thorax posteriorly, ocelli present in macropterous forms; antennae and beak four-segmented. Pronotum produced laterally to form paranota; propleural cavities beneath paranota; prothoracic coxal cavities open. Metapleural scent gland ostiole poorly developed. Legs homomorphous, unarmed; tarsi two-segmented; claws with pseudarolia. Scutellum small, exposed. Hemelytral corium areolate, consisting of four (macropterous) or five (brachyterous) areas, infracostal laminae enclosing connexiva; membrane vestigial, or normal and with four veins and no cells. Hind wing without subcosta; radius and media separate distally. Abdominal spiracles 2 through 5 dorsal on connexivum, 6 dorsal or submarginal, 7 submarginal. Ventral connexival suture apparently lacking; ventral trichobothria sometimes present. Base of hind wing and first abdominal tergite forming stridulatory apparatus in male. Male genitalia symmetrical; endosoma differentiated into conjunctiva and vesica. Seventh sternum of female completely cleft; ovipositor extension geniculate; spermatheca median, unpaired.

Type genus: *Piesma* Le Peletier and Serville 1825: 653 (as subgenus of *Tingis*).

The following keys were formulated to separate the genera of the Piesmatidae of the world and the species in the genera *Piesma* and *Miespa* of the Americas. The only other genus, *Mcateella*, is a tenant of Australia. These keys have been based solely upon specimens in the U. S. National Museum and The Drake Collection, which together include all of the species of the Western Hemisphere as well as almost all of those of the Old World. The holotypes of all American species, except *P. cinereum* (Say) and *P. costatum* (Uhler), repose in the foregoing collections.

In construction of keys, an attempt has been made to employ only those structure that would differentiate equally well species that exhibit both elytral and sexual dimorphisms as they occur in the assemblage of closely related species of the taxon *Piesma*. The members of genera *Miespa* and *Mcateella* are at present known only in the macropterous form. Illustrations are provided to display certain characters employed in the dichotomic keys.

KEY TO WORLD GENERA OF PIESMATIDAE

1. Spiracles 6 and 7 subventral laterally, 2 through 5 dorsal, remote from outer edge of connexiva; pronotum bi- or tricarinate ..... **Piesma**
Only spiracles 7 sublateral ventrally, the others all dorsal; pronotum with or without median carina 2
2. Mesopleura with a pair of prominent, laterally directed, furcate processes (fig. 4); membranate area of hemelytra almost completely coriaceous (fig. 34), the membranous apical part very narrow, without cross veins, so crystal clear and colorless that it is not usually observed in mounted specimens. Australia ..... **Mcateella**
Mesopleura without such processes; membranate area with basal half coriaceous and areolate, the apical half truly membranous, hyaline, and provided with four obliquely transverse veins (figs. 11, 33). Chile ..... **Miespa**

Genus Piesma Le Peletier and Serville

Piesma Le Peletier and Serville 1825: 653 (as subgenus of *Tingis*); Brullé 1835: 342; Spinola 1837: 231; Westwood 1840: 120; Amyot and Serville 1843: 301; Stål 1873: 115; Lethierry and Severin 1896: 1–3; Champion 1897: 2; Horváth 1906: 1–9; Oshanin 1908: 395–400, and 1912: 41–42; Osborn and Drake 1916: 218; Van Duzee 1917: 210; McAtee 1919: 80–86; Parshley 1919: 109; China 1943: 245; Hurd 1946: 436–37; Monte 1947: 2; Kiritshenko 1951: 237–39.
Agrammodes Uhler 1895: 56; Van Duzee 1917: 223 (as serenthiine tingitid).
Aspidotoma Curtis 1833: 196.
Zosmenus Laporte 1833: 49 (as *Zosmanus*, p. 47); Fieber 1845: 308–9 (separate, 1844: 30–31), and 1861: 35 and 116; Flor 1860: 310–17.
Zosmerus Burmeister 1835: 262; Douglas and Scott 1865: 237–38.

Head nearly porrect, moderately depressed; eyes contiguous behind with pronotum; ocelli present in macropterous form, more or less obsolete in brachypterous individuals; juga well-developed, becoming free apically, subequal in length to greatly longer than tylus, when much longer with apices strongly curved inward in front of tylus in female, or pointed forward with

tips often feebly upturned in male; antenniferous tubercles subconical, often distinctly bifid; antennae moderately long, four-segmented, last segment subfusiform to subclavate; bucculae areolate, open in front; labium extending beyond prosternum, the basal segment not shortened. Pronotum transversely subrectangular, coarsely punctate, bi-or tricarinate, sometimes median or lateral pair scarcely distinct, all three usually obsolete behind, surface above propleural cavities (one on each side) rasied so as to form short keel-like ridges; paranota narrow, areolate, with one or more rows of areolae; with outer margin convex, nearly straight or sinuate (concave at middle); mesopleural tubercle small. Metapleural orifice and channel absent or barely visible, feebly developed. Brachypterous and macropterous forms known for most species. Hemelytral areas as in illustration (fig. 7).

Type species: *Acanthia capitata* Wolff (fixed by Brullé 1835).

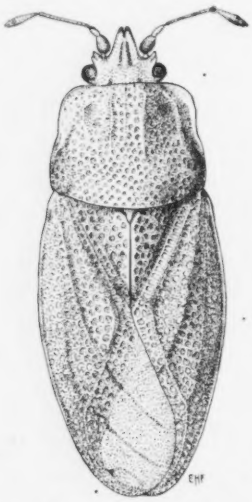


FIG. 28.—*Piesma cinereum* (Say).

As evinced by the generic key, the genus *Piesma* stands apart from the other genera of piesmatids. It embraces a small group of only eight American species, all of which are indigenous, about the same size, similar in habitus and modes of life, and closely related to one another. Variation in coloration, especially degree of maculation, is nearly as marked within a species itself as it is between different species. These variances and deviations together with the striking dissimilarity between macropterous and brahcypterous forms, especially hemelytral areas and reticulation, make it rather difficult at times to understand specific limits as well as to differentiate between species. It should be noted that three species of American piesmatids are represented in our collections by only one form of wing: *Piesma cinereum* and *P. explanatium* entirely by long-winged specimens, and *P. costatum* only by short-winged individuals.

The commonest and most widely dispersed piesmatid of the Americas, *Piesma cinereum* (fig. 28), is a biologic carrier and secretory vector of a virus malady of sugar and garden beets. This disease, named "Savoy" by Coons *et al.* (1937: 125) has been found in many sugar-beet-growing states east of the Rocky Mountains: Colorado, Montana, Wyoming, Nebraska, North Dakota, South Dakota, Texas, Wisconsin, Minnesota, Ohio, Indiana, Maryland and Virginia. It has also been recorded from Ontario, Canada, by Hildebrand and Koch (1942: 177–192). The virus overwinters in both the insect vector and diseased beets. Wild host plants of the virus are as yet unknown. It is also not known whether other members of the genus *Piesma* besides *cinereum* are capable of harboring and transmitting the virus.

Affected beet plants show dwarfed, down-curled and savoyed leaves, the most pronounced effects being displayed by the innermost leaves (fig. 29). The roots of infected plants show phloem necrosis and flesh discoloration in the late stages of disease development. The root yield and the sucrose percentages are much reduced. Incidence of the disease in beet fields range from a trace to around 5 percent, though running much higher in plantings near or adjacent to pasture and timbered areas and especially in beet fields bordering unfarmable tracts and untilled ground that provide suitable hibernating quarters and an abundance of wild hosts and preferred breeding plants for the insect vector. Insofar as known, only the adults, male and female, become viruliferous and transmit the virus disease. Excellent accounts of savoy disease and its vector have been published in technical articles by Coons *et al.* (1937: 125; 1950: 500–501; and 1958: 502–511). These authors emphasize that savoy is symptomologically different from the sugar-beet disease known as Kräuselkrankheit (leaf-crinkle) in Central Europe, as well as entirely distinct from the American beet disease called Curly-Top, which is transmitted by the beet leafhopper *Circulifer tenellus* (Baker).

One of the widely distributed piesmatids of Europe, *Piesma quadratum* Fieber (fig. 30), plays a major role as a biologic carrier and transmitter of the virus which causes Kräuselkrankheit of sugar beet, mangel, and related crops in Germany, Poland, and Czechoslovakia. As with many other members of the genus *Piesma*, the principal host plants of *P. quadratum* belong to the family Chenopodiaceae. At the time of spring migration from hibernating quarters, and again later as wild hosts such as *Atriplex, Salsola, Chenopodium*, and the like become over-populated, macropterous forms of *P. quadratum* emigrate in numbers to

fields of beets, mangels, and related cultivated hosts (Wille 1929). During the past three decades many papers have been published in Europe on Kräuselkrankheit disease of sugar beets, including the interrelations between vector and virus, and wild and cultivated host plants.

On the basis of locality records, the genus *Piesma*, in the Americas, has attained its greatest specific development in the western United States, particularly in the Rocky Mountain and Coastal States, as all of the members of the genus thus far described from the Western Hemisphere occur in these regions. Only the cosmopolite *P. cinereum* is recorded from the eastern United States and Canada; it also inhabits Mexico, Central America, Venezuela, Brazil, Paraguay, Uruguay, and Argentina. Since the fossil described as "*Piesma? rotunda*" by Scudder (1890: 358) from Colorado (Florissant) does not belong to the family Piesmatidae, it is not included in this paper.

FIG. 29.—Sugar Beet Savoy, a virus disease of sugar beets in North America transmitted by *Piesma cinereum*. (Photo through courtesy of Tobacco and Sugar Crop Research Branch, Agr. Res. Service, U. S. D. A.).

Besides the 7 American species of *Piesma* which are treated below, there are 24 species known from the Old World. Of these, 16 are Palaearctic; 6 are Ethiopian; and 2 only are Oriental. The Old World species of *Piesma* are as follows.

bicoloratum Distant 1906; Transvaal, Uganda, Tanganyika.
capitatum (Wolff) 1804; Europe, North Africa, Siberia, Northern Mongolia. =*capitata declivis* and *c. divergens* Rey 1893; =*collaris* (Zetterstedt) 1828; =*maculata* Costa 1838, not Laporte; =*pallida* Costa 1860; =*pedicularis* (Herrich-Schaeffer) 1830; =*stephensi* (Fieber) 1861.
chinianum Drake and Maa 1953; South China (Canton).
convexicollis (Jakovlev) 1874; Russia.
dilutum (Stål) 1855; South Africa.
dispar Schouteden 1956; Belgian Congo.
distans Drake 1940; Bombay.
jugatum Schouteden 1956; Belgian Congo.
kochiae (Becker) 1867; Europe, Turkestan, Caucasus. =*fieberi* (Jakovlev) 1874; =*porcatus* (Horváth) 1874.
kolenatii (Fieber) 1861; Europe, Caucasus, Turkestan. =*atriplicis* Frey-Gessner 1863; =*chenopodii* (Jakovlev) 1874; =*minutus* (Jakovlev) 1871; =*viridulus* (Jakovlev) 1871.
lukugae Schouteden 1956; Belgian Congo.
maculatum (Laporte) 1833; Europe, North Africa, Caucasus, Siberia, Mongolia, Japan; and var. **viridis** (Jakovlev) 1871; Russia, Central Europe. =*anticus* (Fieber) 1845; =*capitata* Costa 1838, not Wolff; =*laportei* (Fieber) 1845.
marginepictum Schouteden 1916; Belgian Congo.
minimum Wagner 1954b; Canary Islands.
pupulum Puton 1879; Spain, Corsica, North Africa.
quadratum (Fieber) 1845; Europe, North Africa, Siberia; and var. **dilatatum** (Jakovlev) 1874; Southern France, southern Russia. =*?clavicornis* (Fabricius) 1775.
rotundatum Horváth 1906; North Africa, Greece, Caucasus; and var. **pygmaeum** Horváth 1906; Syria. =*atriplicis* Stål 1874, not Frey-Gessner.
rotundicollis Rey 1888; Europe.

salsolae (Becker) 1867; Central Europe, Russia, Greece. =*kolenatii* (Jakovlev) 1874, not Fieber.
silenes (Horváth) 1888; Hungary.
suaedae Wagner 1955; Dalmatia.
tenellum Horváth 1906; Asia Minor.
unicolor Wagner 1954a; Norway.
variabilis (Fieber) 1845; Europe, North Africa, Siberia. =*maculatus* (Jakovlev) 1874, not Laporte; =*variabilis brevicornis* Rey 1888.

KEY TO AMERICAN SPECIES OF GENUS PIESMA

1. Paranota broadly explanate in front of humeral angles, with or without intercalated areoles anteriorly, lateral margins rectate (fig. 31c) ..... **P. explanatum**
   Paranota narrower, entirely uniseriate or uniseriate to calli and then biseriate, in either case with or without interposed areolae anteriorly, lateral margins feebly to deeply incurved at middle, thus sinuate (fig. 31a, 31b) 2
2. Femora almost entirely blackish fuscous, or with only a fuscous band near middle 3
   Femora entirely ochraceous or stramineous, rarely lightly embrowned 4
3. Femora almost wholly (and also, usually, basal antennal segments) dark to blackish fuscous ..... **P. proteum**
   Femora with only a narrow fuscous band near middle (color form) ..... **P. cinereum**
4. Pronotum narrower in front than behind; third antennal segment at least one-fourth longer than fourth segment 5
   Pronotum with basal and apical widths subequal, often only slightly narrower in front; third and fourth antennal segments subequal in length, the latter frequently just slightly shorter 6
5. Third antennal segment almost one-half longer than fourth segment; inner basal part of membrane area of hemelytra reticulately coriaceous, its apical margin adjacent to membranous part straight (figs. 28, 31a) ..... **P. cinereum**
   Third antennal segment not more than one-fourth longer than fourth segment; reticulate, coriaceous part of membrane with apical margin sinuate, distinctly incurved and quite concave between veins 2 and 3 ..... **P. patruele**
6. Pronotal carinae feebly developed, not always distinct, tortuous; transocular width of head scarcely 0.50 mm. (fig. 32) ..... **P. costatum**
   Pronotal carinae plainly visible, nearly straight; width of head across eyes not less than 0.55 mm. 7
7. Cubital area of hemelytra distinctly narrower than brachial area ..... **P. brachiale**
   Cubital area subequal to or wider than branchial area ..... **P. ceramicum**

Piesma cinereum (Say)

Figures 28, 31a

Tingis cinerea Say 1832: 27 (Fitch reprint 793; Compl. Writ. 1: 349).
Piesma cinerea, Stål 1873: 116; Summers 1891: 90; Uhler 1894: 278; Gillette and Baker 1895: 56; Lethierry and Severin 1896: 2; Champion 1897: 2; Osborn and Drake 1916: 218; Van Duzee 1917: 210; McAtee 1919: 86–88; Parshley 1923: 694; Barber 1924: 229–32; Weiss and Lott 1924: 233–35; Blatchley 1926: 447; Drake and Hambleton 1938: 51; Monte 1941: 70; Hurd 1946: 436.
Piesma cinerea inornata McAtee 1919: 88 (NEW SYNONYMY).
Piesma cinerea floridana Blatchley 1926: 448 (NEW SYNONYMY).

Macropterous form only known. Color and markings quite variable; ground color cinereous or stramineous, sometimes tinged with brownish or greenish, innotate or variegated with small spots, marks, or blotches of brown, fuscous, and blackish; legs stramineous or ochraceous, femora occasionally narrowly banded near middle with dark fuscous, head often largely black. Paranota uniseriate, frequently with additional areoles anteriorly. Juga always greatly surpassing tylus. Elytral areolation as in figure 7. Length, 3.50 mm.

Since the color variations or variants blend deeply into one another, *P. cinerea inornata* McAtee and *P. cenerea floridana* Blatchley are here relegated to synonymy as representing merely color variations of typical *cinereum*.

The primary host plants of *P. cinereum* are amaranths and chenopods, especially species of the genera *Amaranthus*, *Chenopodium*, *Salsola* and *Atriplex*. Not infrequently, specimens have been netted on the foliage of truck and field crops, fruit and forest trees, and numerous herbs and grasses. Pinned specimens frequently bear such plant data as wild or cultivated grapes, sugar or garden beets, chard, lettuce, corn, clover, alfalfa, and apple. During migrations and fortuitous flights *cinereum* and other piesmatids, by chance or otherwise, often alight upon or are stranded on plants which do not serve them as breeding hosts. Not much is really known concerning the feeding and breeding hosts, including both wild and cultivated plants.

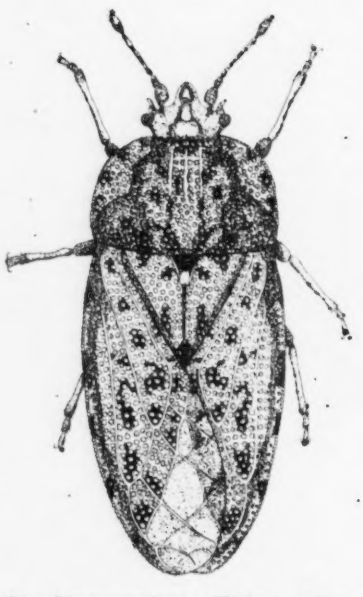


FIG. 30.—*Piesma quadratum* (Fieber), of Europe. (After Wille).

Winter is passed in fairly dry, protected areas beneath fallen leaves, grasses, and various sorts of litter and rubbish on the ground. Timbered areas, ravines, fence rows and other untilled and

grassy areas provide suitable cover and sheltered haunts.

According to Forbes and Hart (1900: 433) the adults of *P. cinereum* occasionally become very abundant in central Illinois, and to quote from these authors: "Their occasional abundance is illustrated by the fact that an immense swarm of this species was noticed at Normal, Illinois, October 3rd, the insect flying in great numbers high in the air from three to five in the afternoon."

Barber (1924: 233) published a brief account of the life history and breeding habits of *cinereum*, including figures of immature stages and adults. As the adults are rather sluggish, quiescent, and thus not easily disturbed, the species lends itself fairly well to manipulations in field and laboratory experiments.

P. cinereum is the only member of the genus so far known to occur in the eastern half of United States and Canada. It ranges clear across southern Canada, throughout the entire United States, then south through Mexico, and Central America, across Venezuela, Brazil, Paraguay, Uruguay, and into Argentina. Specimens have been examined from all the foregoing countries and from almost every state in the United States. So far, *cinereum* has not been recorded from Ecuador, Peru, Chile and the Guianas, and it is the only member of the genus known to occur in Central and South America.

Piesma brachiale McAtee

Piesma brachialis McAtee 1919: 88.

Ground color stramineous with reticulation lightly embrowned, sometimes stippled with dark fuscous spots. Structural characters as in key. Long- and short-winged forms known. Length, 2.50-2.85 mm.

According to McAtee, the types from Arizona and Utah were collected on *Isocoma* (*Bigelovia*) *hartwegi* by H. G. Hubbard. We have also studied a long series of specimens from Nogales and Patagonia, Arizona, August 23, 1937, netted by Drake and Andre.

Piesma patruele McAtee

Piesma patruela[1] McAtee 1919: 86.

Macropterous and brachypterous forms represented. Pronotum with carinae poorly developed, moderately swollen at hind humeri. Head largely blackish fuscous; pronotum and hemelytra pale cinereous to brownish, often mottled with small fuscous spots or larger markings. Closely allied to *P. cinereum*, but easily distinguished by the key characters. Length, 2.25–2.75 mm. Host plant: *Chenopodium album* L.

The types were taken in Arizona and Texas (Cotulla): Other specimens are at hand from Texas (Laredo, VI.3.1953; Bexar Co., IV.29.1941) and from Arizona (Sedona, IV.9.1940), all collected by P. W. Oman.

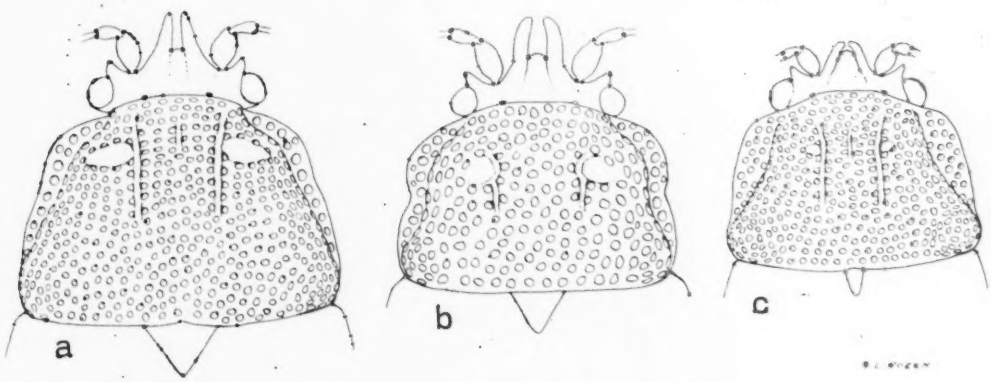


FIG. 31.—Head and pronotum of (a) *Piesma cinereum* (Say), (b) *P. costatum* (Uhler), (c) *P. explanatum* McAtee.

Piesma costatum (Uhler)

Figures 31b, 32

Agrammodes costatus Uhler 1895: 56; Van Duzee 1917: 223 (as in tribe Serenthiini of family Tingididae).
Piesma costata, McAtee 1919: 90.
Piesma costata defecta McAtee 1919: 91 (NEW SYNONYMY).

Brachypterous form only known. Color whitish cinereous to stramineous, hemelytral veins more or less brownish or fuscous, often with spots and markings on dorsal surface. Separation characters as in key. Length, 2.00–2.25 mm.

Type: Estes Park, Colorado, No. 1133, not seen. Other specimens from Colorado and Ari-

[1]McAtee evidently intended this as an adjectival specific name rather than a noun in apposition, but overlooked the fact that in this third-declension Latin adjective the feminine nominative singular is *patruelis*. Since the present Rules require that adjectival specific names in *Piesma* shall be neuter to agree with the generic name, this one must now be written *patruele*.

zona, determined by McAtee, are at hand. The variety *defecta* McAtee is suppressed as a synonym, as it is only a color variant of typical *costatum*. The food plant of this species is unknown.

Piesma proteum McAtee

Piesma protea McAtee 1919: 89.
Piesma depressa McAtee 1919: 91. (NEW SYNONYMY.)
Piesma incisa McAtee 1919: 91. (NEW SYNONYMY.)

Stramineous or pale fuscous, usually with some fuscous spots and maculations; lateral carinae of pronotum reduced. Femora almost entirely dark fuscous. Length, 2.25–2.90 mm.

Examination of the type series of *P. proteum*, *P. depressum*, and *P. incisum* shows that these three names apply to a single species. Since *P. proteum* has page priority it becomes the valid name for the species, the two other names being junior synonyms.

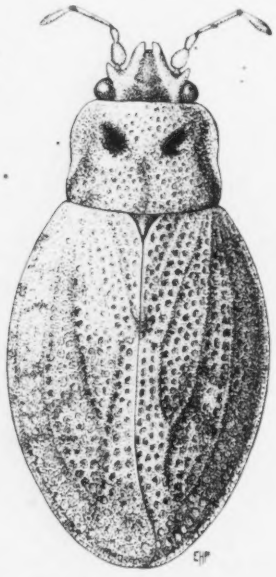


FIG. 32.—*Piesma costatum* (Uhler).

In addition to the types from Arizona, Utah, and Nebraska, specimens have been studied as follows: ARIZONA (Tucson, VI.18.1953, P. W. Oman); UTAH (Monument, VI.9.1930, on *Atriplex*, G. F. Knowlton; Cedar Mountains, Tooele County, VI.6.1953, on *Suaeda torreyana*, P. D. Ashbrook); NEVADA (Mesquite, Clarke County, IX.6.1953, breeding in large numbers on *Suaeda torreyana*); and COLORADO (Grand Junction, VII.28.1900, E. D. Ball).

Piesma ceramicum McAtee

Piesma ceramica McAtee 1919: 89.
Piesma rugulosa McAtee 1919: 89. (NEW SYNONYMY.)

Color stramineous, more or less bespeckled with fuscous or blackish. Pronotal carinae nearly straight. Distinguishing characters as in key. Length, 2.25–3.00 mm.

The types of *P. ceramicum* (three females) and *P. rugulosum* (one male) are not separable and represent only a single species. As the former name appears first on the same page, *rugulosum* becomes a junior synonym.

Type: Courthouse, Utah; of *rugulosum*, Rocky Ford, Colorado, taken on greasewood by H. O. Marsh together with numerous other specimens. Many specimens also are at hand from COLORADO (Huerfano, IV.13, L. D. Tuthill) and ARIZONA (Tombstone, VII.27.1941).

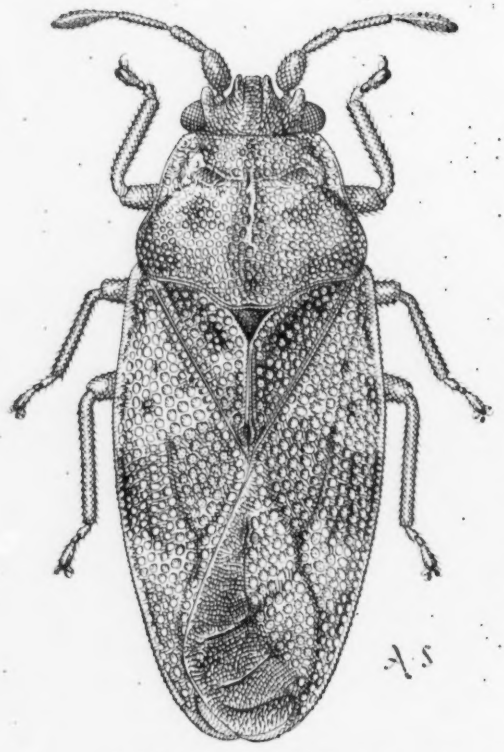


FIG. 33.—*Miespa reedi* (Drake).

Piesma explanatum McAtee

Figure 31e

Piesma explanata McAtee 1919: 91.

Known only from the slightly teneral, macropterous, female type, netted near the mouth of Bear River, Utah; the host plant is unknown. Length 3.00 mm. Easily separated from its congeners by the key characters and by the figure given herewith of pronotum and head.

Genus Miespa Drake

Miespa Drake 1948: 73–74.

Small. Head broad, wider than long, slightly

depressed, sloping gently anteriorly; juga and tylus subequally prolonged in front; eyes lateral, exserted, widely separated. Labium moderately long, reaching beyond prosternum; sulcus well developed on prosternum, thence incompletely formed. Antennae rather short, with first segment inerassate and fourth subclavate, other two segments more slender. Pronotum subrectangular, coarsely punctate, swollen across humeri, slightly, convexly produced at middle behind, median carina fairly distinct; paranota narrow, areolate, not longer than pronotum. Metapleural orifice of stink gland indistinct. Hemely-

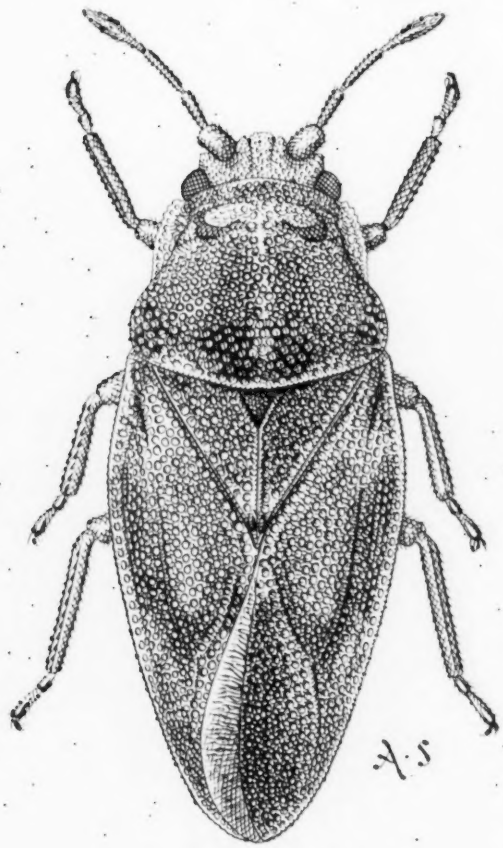


FIG. 31.—*Mcateella gibber* Drake.

tra finely reticulate, divided into areas as shown in figure 33; membrane with approximately the basal half coriaceous and areolate, the distal half membranous and provided with four oblique veins, the cells open behind.

Monobasic. Type species: *Mcateella reedi* Drake.

As noted elsewhere, this genus is much more closely related to the Australian *Mcateella* than to the almost global *Piesma*.

Miespa reedi (Drake)

Figure 33

Mcateella reddi Drake 1939: 331.
Miespa reedi, Drake 1948: 74.

Color somewhat variable, cinereous with head reddish brown, pronotum partly embrowned, a wide brownish or light fuscous band extending more or less across middle of hemelytra, also a few veinlets beyond fasciae partly embrowned; veinlets of membrane brownish to infuscate. Antennae short, slightly reddish brown, sparsely, finely granulate; first segment moderately swollen, extending about two-thirds of its length beyond juga; fourth subclavate, longer than first, third subequal in length to first, slightly more slender and barely longer than second. Legs stramineous, with a tinge of brown; second tarsal segment blackish. Female abdomen beneath as in figure 16. Length, 2.65 mm.

Holotype (male), Central Provinces, Chile, Drake Collection (U.S.N.M.). Other specimens are at hand from Santiago, Chile. Host plant unknown. A male is illustrated in figure 33.

Genus **Mcateella** Drake

Mcateella Drake 1924: 84–85; Hacker 1927: 30–31.

This genus is represented by four species, all from the mainland of Australia, namely, *M. splendida* Drake (1924: 86), the genotype, from Queensland; *M. elongata* Hacker (1927: 30–31), Queensland; *M. interioris* Hacker (1928: 187), South Australia; and *M. gibber* Drake (1958: 46) (fig. 34), Western Australia. According to Hacker (1927), *M. splendida* was taken in numbers on the flowers of *Acacia cunninghami* (Leguminosae), probably its host plant, and *M. elongata* on the flowers of *Acacia decurrens*.

Though all three genera of Piesmatidae are quite distinct and easily separated from one another by the generic key and illustrations, *Mcateella* of Australia and *Miespa* of Chile have more features in common and are more closely related to each other than to the common and almost worldwide *Piesma*. The features of the head, hemelytra, and other structures appear to indicate strongly that the genus *Mcateella* is slightly more generalized and perhaps older than *Miespa*, and that *Piesma* represents a taxon of later origin, though not recent. There appear to be no undoubted fossil records of piesmatids.

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THE LARVAE OF CHAULIODES LATREILLE (MEGALOPTERA: CORYDALIDAE)[1]

R. DUNCAN CUYLER

ABSTRACT

Larvae of *Chauliodes* differ from those of other North American genera of Megaloptera by having the spiracles of the 8th abdominal segment at the ends of two unequal, elongated tubules. The larvae of the two Nearctic species, *C. rastricornis* and *C. pectinicornis*, have been confused in the past but can be separated by the degree of inequality and the length of the tubules, and by the color of the prothoracic and abdominal dorsum. Larvae of Chauliodinae and of *Corydalis* are compared, generic larval characters of *Chauliodes* are given, and larvae of the two species are described from material collected in North Carolina.

The family Corydalidae is divided into the subfamilies Corydalinae and Chauliodinae. Prior to 1908, all species of Chauliodinae were included in the genus *Chauliodes* Latreille 1807. The five genera of Chauliodinae now recognized in the Nearctic region are *Chauliodes*, *Dismycohermes* Munroe 1953, *Protochauliodes* Van der Weele 1909, *Neohermes* Banks 1908, and *Nigronia* Banks 1908. *Chauliodes* contains two North American species, *C. rastricornis* Rambur and *C. pectinicornis* (Linnaeus), both of which are largely restricted to the eastern United States. As a result of a number of inconsistencies found in the literature, the true identities of the larvae of these two species have not been established heretofore.

Larvae and pupae of various Chauliodinae, including both species of *Chauliodes*, were collected by the writer in east-central North Carolina, chiefly in Durham, Wake, and Orange Counties. Attempts were made on a number of occasions to rear the immature forms. No larvae were reared from ova, but several of the larvae and pupae completed their development to the adult stage. Other larvae were placed in KAAD solution or boiled to coagulate the proteins and insure against disfiguration when subsequently placed in alcohol.

The initial identification of the *Chauliodes* larvae collected by the writer was based on the following circumstances. Certain larvae possessed markings on the prothorax and abdomen which were identical with markings on those body parts of *Chauliodes pectinicornis* adults. This finding indicated that these larvae also were *pectinicornis*, and that the larva of this species can be identified by means of a yellow stripe on the middorsum of the prothorax and abdomen.

It was noted also that other chauliodine larvae, collected prior to the *pectinicornis* larvae, possessed a black middorsal stripe on the thorax and abdomen. Subsequently, when the first of the *pectinicornis* larvae was collected, it was apparent that a different species of larva had been taken. When it was determined that this second larva belonged to *pectinicornis*, it was suspected that specimens of the other species belonged to *rastricornis*. Both species possessed caudal respiratory tubes (tubes subtending the spiracles of the eighth abdominal segment), indicating that they were congeneric.

Later, a preserved pupa of *rastricornis* was examined. It possessed a dark middorsal stripe

Table 1.—Differences between larvae of *Corydalis* and of Chauliodinae

Structure	*Corydalis*	Chauliodinae
Labrum	elongate (fig. 4)	transverse (fig. 7)
Lateral margin of gena	strongly angulate (fig. 4)	convex or weakly angulate (fig. 7), except in *Dismycohermes*
Mandibles	symmetrical (fig. 4)	asymmetrical (fig. 7)
Antennae	5-segmented	4-segmented
Lateral filaments	carinate; tufted with hairs on abdominal segments 1–8 (fig. 6)	not carinate; not tufted with hairs on abdominal segments 1–8 (fig. 8)
Spiracles	cribriform	annular
Tufts of tracheal gills on abdominal venter	present (fig. 6)	absent (fig. 8)
Spiracles of 8th abdominal segment	near base of lateral filament (fig. 5)	at posterior margin of segment (fig. 10), or at end of respiratory tube (*Chauliodes*, fig. 9)
Hydrofuge hairs on 9th abdominal ventrite	present	absent
Clavate macro- and microsetae	present	absent

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on the abdomen, as do larvae of this species. Still later, a large number of pupae of this species, as well as larvae preparing to pupate, were collected. Two adults, a male and a female, were reared from pupae; and three males and three females were reared from larvae. All of these adults, and a number of adults subsequently collected, possessed abdominal markings like those of the larvae and pupae.

DESCRIPTIONS

The descriptions presented here are based chiefly upon larvae more than 25 millimeters in length. It happens that some specimens may be stretched more than others by the KAAD solution. Consequently, two preserved specimens which are apparently of the same length may not have been of the same size originally.

SUBFAMILY CHAULIODINAE

Table 1 sets forth the major differences between larvae of this subfamily and those of the Corydalinae, as represented by the very well-known *Corydalis cornuta* (figs. 1, 4, 5, 6). In the Chauliodinae the left mandible bears an additional tooth apical to the three regular teeth. Larvae of the genus *Dismycohermes* are exceptional in the Chauliodinae in that the gena is strongly angulate, as it is in *Corydalis*.

Genus Chauliodes

Larvae of this genus may be recognized immediately by the presence of a pair of long, unequal tubules bearing the spiracles of the eighth abdominal segment.

Prothorax quadrangular, approximately $1\frac{1}{4}$ times broader than long; lateral filaments narrow, nearly threadlike in appearance; spiracles of abdominal segments 1 to 7 located slightly anterior to level of bases of lateral filaments, nearly sessile; spiracles of segment 8 located at ends of long respiratory tubes arising close to-

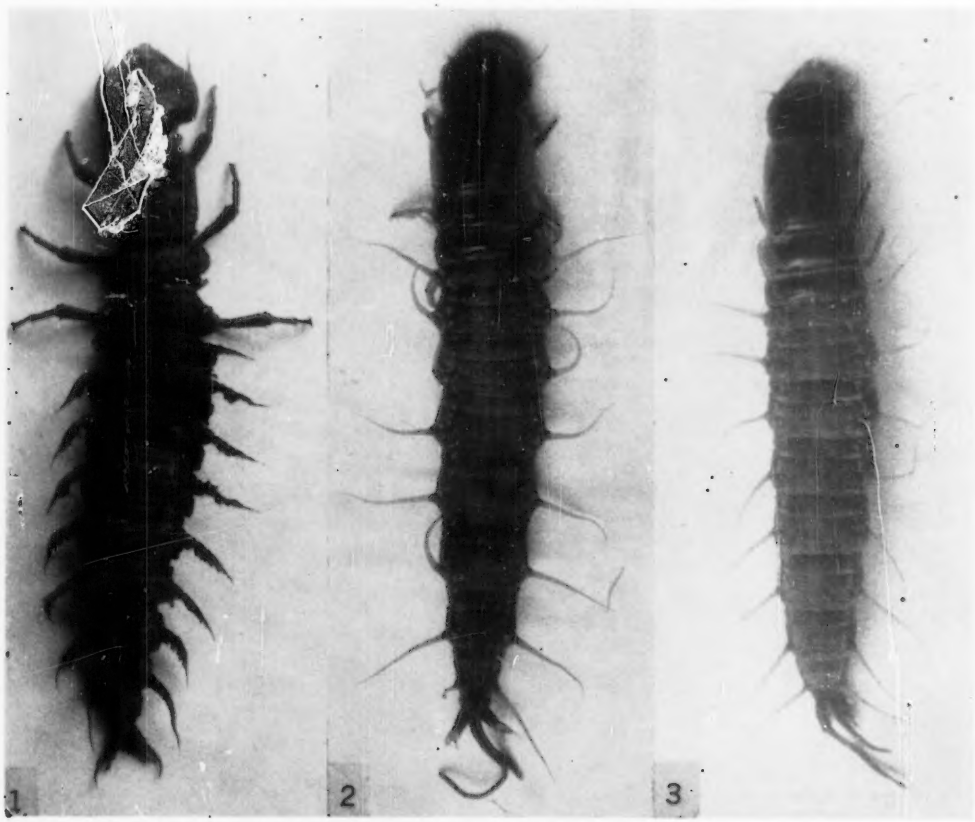


FIG. 1.—*Corydalis cornuta* (Linnaeus). Preserved specimen from Little Creek, Orange County, North Carolina, March 10, 1956. Natural size. FIG. 2.—*Chauliodes rastricornis* Rambur. Living specimen from American Legion Pond, Fuquay-Varina, North Carolina, March 29, 1956. Enlarged x1.5. FIG. 3.—*Chauliodes pectinicornis* (Linnaeus). Preserved specimen from swamp, Durham County, North Carolina, August 16, 1953. Enlarged x2.3.

gether from posterior margin (fig. 9); respiratory tubes unequal, the longer one on either left or right; hairs longest on abdomen, irregular in length on lateral margin of head; abdomen and lateral filaments with small papillae scattered thinly over surface; legs with spines.

Habitat.—Lenitic bodies of water, including lakes, ponds, and swamps; pupation chiefly in decaying logs or stumps above water level or on adjacent land.

KEY TO LARVAE OF *CHAULIODES*

Longer respiratory tube as long as combined length of abdominal segments 6 to 8 or 5 to 8, shorter tube $^3/_{10}$ to $^2/_3$ as long as longer one; abdomen with black middorsal stripe ..... **C. rastricornis**

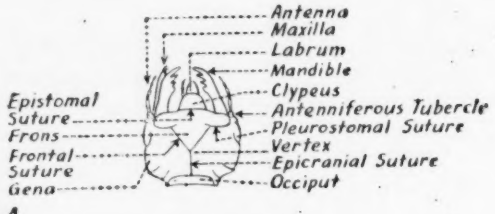
Longer respiratory tube as long as combined length of abdominal segments 7 and 8, shorter tube $^1/_2$ to $^4/_5$ as long as longer one; abdomen with yellow middorsal stripe ..... **C. pectinicornis**

Chauliodes rastricornis Rambur

Figure 2

Length 34.0 mm.; head 5.5 mm. wide; occipital suture convex, sinuate, not concave middorsally; pronotum 4.5 mm. long, 5.75 mm. wide; first abdominal segment slightly more than twice as wide as long; proleg 1.15 mm. long, claws 0.35 mm.; lateral filament of first abdominal segment as long as width of segment, filament of eighth segment $2^1/_2$ times longer than width of segment, filament of proleg surpassing claws by length of claws; spiracles 0.15 mm. in diameter; longer respiratory tube as long as combined length of segments 5 to 8 or 6 to 8 (8.0 mm.); shorter respiratory tube 0.3 to 0.67 length of longer tube; hairs longer than those of *C. pectinicornis*, those of lateral filaments distinctly longer than basal diameter of filament.

Labrum reddish brown; clypeus yellow; frons and vertex brown, obscurely phalerate with reddish and with tawny streaks immediately mesad of lateral margin; occiput reddish brown with minute dorsolateral black streak; prothorax tawny, mottled with black and brown and with dark brown middorsal stripe 0.2 mm. wide at top and abruptly narrowing to 0.1 mm.; meso- and metathorax tawny, with dark brown middorsal stripes, submedian vertical streaks, and irregular brown lateral areas; legs yellowish; abdomen yellowish gray mottled with brown, with middorsal brown streak 0.5 mm. wide and with a



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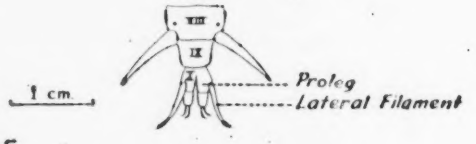

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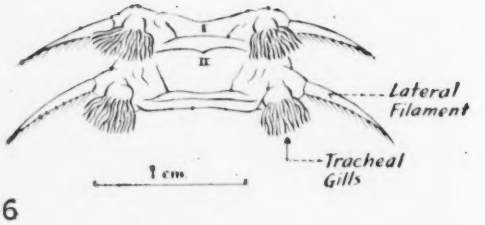

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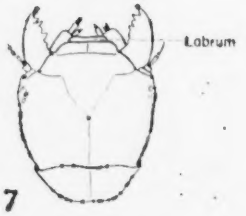

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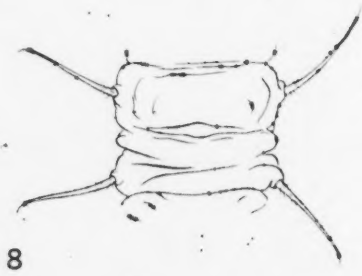

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FIG. 4.—*Corydalis cornuta*. Dorsal view of head. (Line drawing by Louise Horne, Mt. Zion Hospital, San Francisco, California.)

FIG. 5.—*Corydalis cornuta*. Caudal end of abdomen, dorsal view. (Line drawing by Louise Horne.)

FIG. 6.—*Corydalis cornuta*. Venter of first and second abdominal somites. (Line drawing by Louise Horne.)

FIG. 7.—*Chauliodes pectinicornis*. Dorsal view of head. (Line drawing by Department of Medical Art and Illustration, Duke Hospital, Durham, North Carolina.)

FIG. 8.—*Chauliodes pectinicornis*. Venter of first and second abdominal somites. (Line drawing by Department of Medical Art and Illustration, Duke Hospital.)

somewhat narrower line one-third the distance from middorsum to lateral margin, also with oblique, divergent, dorsolateral and lateral brown stripes; venter yellowish brown with black spots on centers of segments; lateral filaments yellowish.

Chauliodes pectinicornis (Linnaeus)

Figures 3, 7, 8, 9

Length 38.0 mm.; head 5.5 mm. wide; occipital suture sinuous, concave at middorsum; pronotum 5.0 mm. long, 6.3 mm. wide; abdomen 6.0 mm. wide; first abdominal segment slightly more than 3 times wider than long; proleg 1.25 mm. long, claws 0.5 mm.; lateral filament of first abdominal segment four-fifths as long as width of segment, filament of eighth segment twice as long as width of segment, filament of proleg surpassing claws by $1\frac{1}{2}$ times length of claws; spiracles 0.25 mm. in diameter; longer respiratory tube as long as combined length of segments 7 and 8 (5.0 mm.), shorter tube 0.5 to 0.8 length of longer tube; hairs shorter than those of *C. rastricornis*, those of lateral filaments but little longer than basal diameter of filament.

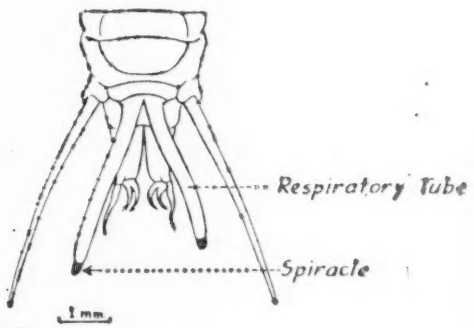
Labrum tawny; clypeus whitish; frons, vertex, and occiput dark brown, mottled with yellowish; pronotum brown, mottled and figured with yellow, including a Capital-I-shaped middorsal band on basal two-fifths and a figure "2" near base dorsolaterally; scuta of meso- and metathorax brown with irregular yellow longitudinal, dorsolateral and lateral markings; legs yellow; abdomen brown or purplish brown (sometimes pink in boiled specimens) with middorsal, dorsolateral, and lateral yellow stripes; venter yellowish with light brown spot posterior to suture; lateral filaments whitish.

REVIEW OF LITERATURE

Larvae of *Chauliodes* were collected and described for the first time by Walsh (1863), who reared an unstated number of *C. rastricornis* from the Mississippi River at Rock Island, Illinois. Although he described the larvae in considerable detail, the characters which distinguish larvae of *rastricornis* from those of *pectinicornis* were not mentioned.

Moody (1877) described two *Chauliodes* larvae, stating that they possessed a "black, interrupted, mediodorsal line, and a narrower, more obscure, similar line each side." It is clear, therefore, that these larvae were *C. rastricornis*. Moody determined an adult reared from one of these larvae as *C. pectinicornis*. This was evidently a misidentification on the basis of the antennal structure. Formerly specimens possessing pectinate antennae were classified as *C. pectinicornis*, those with serrate antennae as *C. rastricornis*. However, it was noted by Weed (1889) and by Needham and Betten (1901) that the males of *rastricornis* also possess pectinate antennae.

Weed (1889) redescribed the larvae of *Chauliodes rastricornis*. His description was more detailed than that of Walsh (1863), and was accompanied by figures of a larva, a pupa, an adult male, and an adult female. He mentioned a dark middorsal stripe on the thorax. The caudal repiratory tubes are not mentioned in the description, but the illustration shows them as equal in length—unlike the tubes of the specimens collected by Walsh, by Brimley (1908), and by the present writer. The length of the tubes appears to be equivalent to the combined length of abdominal segments 5 through 8, as is true of the longer tube in larvae collected by the writer.



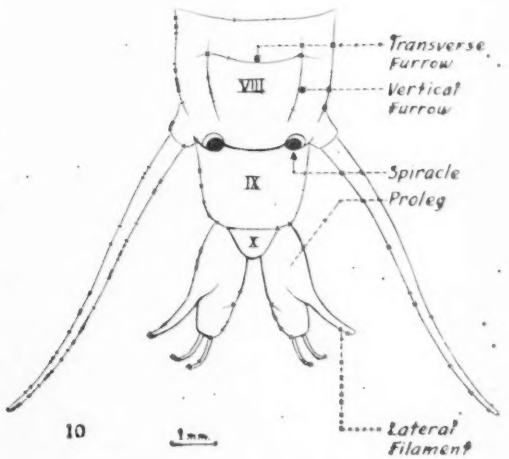


FIG. 9.—*Chauliodes pectinicornis*. Caudal end of abdomen, dorsal view. (Line drawing by Louise Horne.)
FIG. 10.—*Neohermes californicus* (Walker). Caudal end of abdomen, dorsal view. (Line drawing by Louise Horne.)

Riley (1879) compared larvae of *Chauliodes* with those of *Corydalis cornuta*.

Lintner (1892), like Moody, identified a larva of *Chauliodes rastricornis* as *C. pectinicornis*. He quoted Moody's description, but mentioned

no particulars in which his larva might have differed from one reared by Moody. In the accompanying illustration by Bridgham, the unequal length and proportions of the caudal respiratory tubes appear the same as observed by the present writer on *rastricornis* larvae.

Needham and Betten (1901) gave an account of their observations on the larvae, pupae, and adults of *Chauliodes*. Their references involving chauliodine larvae are based on misdeterminations, or leave doubt as to which species is concerned. Larvae of *Nigronia serricornis* (Say) were tentatively identified by these authors as *Chauliodes pectinicornis*, while larvae of *Chauliodes* in the modern sense were tentatively identified as *C. serricornis* and *C. rastricornis*. Their "*serricornis*" identification was based on a comparison with larvae possessing unequal respiratory tubes, reared and identified as *serricornis* by Henshaw (see Needham and Betten, 1901, p. 545, footnote 1). They noted that these larvae agreed with Lintner's (1892) illustration of "*pectinicornis*," which they concluded was a misdetermination. Their "*rastricornis*" identification was based on Weed's (1889) illustration, and applied to a species with respiratory tubes of "about equal" length. But in true *pectinicornis* the respiratory tubes are more nearly equal than in true *rastricornis*. It is likely, therefore, that the "*rastricornis*" larvae of Needham and Betten are the true *pectinicornis*. However, Needham and Betten actually did not mention the characteristics which separate larvae of these two species, and their authentic *Chauliodes* larvae could have belonged to either or both, as far as can be determined at this time.

Davis (1903), in his revision of the Sialidae (including Corydalidae) of North and South America, referred to larvae with long, unequal, respiratory tubes as *Chauliodes serricornis*.

Brimley (1908) collected *Chauliodes* larvae in Wake County, North Carolina. These larvae, which possessed unequal respiratory tubes, were reared to adults. Ten adults were determined by Brimley as *Chauliodes pectinicornis*, eight as *C. rastricornis*. Since he based his determinations on the antennal structure, any number of the adults determined as *pectinicornis* could have been males of *rastricornis*.

Parfin (1952) collected prepupae (larvae preparing to pupate) of *C. rastricornis* and reared them to adults. She did not describe the larvae, but her determinations of the adults are thought to be reliable.

ACKNOWLEDGMENTS

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A CONTRIBUTION TOWARD A MONOGRAPH OF THE SCATOPSIDAE (DIPTERA). PART VII. THE GENUS PSECTROSCIARA KIEFFER[1]

EDWIN F. COOK[2]

ABSTRACT

The genus and all its previously known species are redescribed and illustrated, with type data and type localities included where available. Eleven new species are described, one each from Oregon, Jamaica, Chile, and Iran, respectively; three from Texas, and four from California. A key is given to the North American forms. On the basis of adult morphology, the species fall into two groups, the *Brunnescens* group and the *Scatopsiformis* group, respectively.

The genus *Psectrosciara* Kieffer has had a rather confused nomenclatural history. The first generic description was given by Enderlein (1911) under Kieffer's name, in a direct quotation from manuscript descriptions by Kieffer which appeared, though not until the following year, as an appendix to another paper by Enderlein (1912a). *P. mahensis*, the type species designated by Kieffer, was not described in 1911 but was merely cited by name. In the 1912 paper, however, this type species was described from the two available specimens from Mahe, Seychelles Islands. In these two early papers only the type species was included in the genus. Subsequently, Enderlein (1912b) described an additional species, *P. scatopsiformis*, based on a single female from Costa Rica. Duda (1928) redescribed the latter from additional material, and also described a new variety, *P. s. mexicana*. Edwards (1927) indicated, after examining the types of *P. mahensis* and *Scatopse brunnescens* Brunetti (1911) from Ceylon, that *S. brunnescens* and *P. mahensis* are synonyms.

In Kieffer's original description, the antennae of *P. mahensis* are described as having 2+14 segments. Enderlein (1912b) indicated that the antennae are 10-segmented. Upon inquiry, I have been informed by Dr. Paul Freeman (*in litt.*) of the British Museum that the type has no head. However, the other specimen from the same collection identified by Enderlein has 9-segmented antennae. This is true also of *S. brunnescens* Brunetti. On the strength of Edwards' opinion, *P. mahensis* will be considered a junior synonym of *S. brunnescens*.

This genus was placed originally by both Kieffer and Enderlein in the Sciaridae, but Enderlein (1912b) subsequently placed it properly in the Scatopsidae. Edwards (1914, 1925, 1930) has indicated that *Anapausis* Enderlein and *Ectaetia* Enderlein are synonymous with it, and has consequently described a species of each under *Psectrosciara*. Neither of these genera are synonyms as will be demonstrated in subsequen papers.

In addition to *P. brunnescens* (Brunetti) (=*P. mahensis* Kieffer), *P. scatopsiformis* Enderlein, and *P. s. mexicana* Duda, the following species have also been described which belong in this genus: *P. brevicornis* Johannsen, *P. luzonensis* Edwards, *P. californica* (Cole), and *P. novoguiniensis* Duda (Konowia 7: 271–2). The last named species is based on a single female which was deposited in the Hungarian National Museum. Since recent information indicates the loss of all of the types of Diptera housed there, and since the description is not adequate for unequivocal recognition, this species must be treated as a *nomen dubium*. The type of *P. s. mexicana* should be in the University of Berlin, but it is apparently not there. The type of *P. californica* (Cole) has also been lost according to information received *in litt.* from Pomona College where it was deposited. The type of *P. luzonensis* Edwards is in the Helsinki Museum (No. 2141) and was made available to me through the courtesy of Dr. Richard Frey. The type of *P. brevicornis* Johannsen is in the Cornell University collection (No. 2390) and was made available to me through the courtesy of Dr. Henry Dietrich. In addition to these types, I have been able to examine four specimens (2 ♀♀, 2 ♂♂) of *P. brunnescens* (Brunetti) from Ceylon. The latter specimens were kindly made available to me by Dr. Paul Freeman. The type of this species is in the Indian Museum at Calcutta. The type of *P. scatopsiformis* Enderlein is in the Stettin Entomological Museum. No type has been available, but the description is adequate to identify Central American material available to me.

In the remaining material available there are eleven previously undescribed species from South and Central America, from western and southwestern United States, and from Iran. These will herein be described, and the previously described species will be redescribed on the basis of available specimens.

In the course of this investigation it has become clear that this genus is composed of two distinct groups. The typical group contains *P. brunnescens*, *P. luzonensis*, *P. brevicornis*, and six

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previously undescribed species from western and southwestern U. S. and Iran. The other group contains *P. scatopsiformis*, *P. californica*, and five previously undescribed species from western and southwestern United States, South America, and the West Indies. These will be considered as the *Brunnescens* and *Scatopsiformis* groups, respectively.

The immature stages of the species in this genus are entirely unknown.

Psectrosciara Kieffer

Psectrosciara Kieffer, 1911, *in* Enderlein, Arch. Naturgesch. 77, 1, Suppl. 3, pp. 192-3; Kieffer, 1912, *in* Enderlein, Trans. Linn. Soc. London, Zool. 15: 192-3; Enderlein, 1912, Trans. Linn. Soc. London, Zool. 15: 192; Enderlein, 1912, Zool. Anz. 40: 280-4; Melander, 1916, State Coll. Wash. Agric. Expt. Sta. Bull. 130, p. 16; Edwards, 1925, (in part) Ann. Appl. Biol. 12: 270-4; Duda, 1928, *in* Lindner, Die Fliegen der palaearktischen Region, 2, fasc. 5, p. 9; Duda, 1928, Konowia 7: 271-2, 290-4; Edwards, 1930, (in part) Diptera of Patagonia and South Chile, pt. 2, fasc. 3, p. 97. Type species: *P. mahensis* Kieffer = *P. brunnescens* (Brunetti).

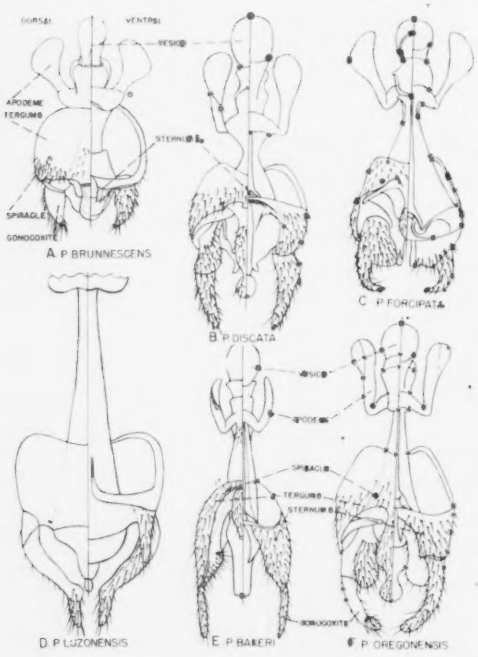

FIG. 1.—A–F, Male genitalia of *Psectrosciara* species.

Generic Description

The specimens of this genus available to me are among the larger of the Scatopsidae, ranging in length from 2.00 to 3.10 mm. In form they are all slender and elongate with very long anterior coxae. The color ranges from a greyish yellow through greyish brown to very dark brownish black. In some species the prothoracic legs are conspicuously darker than the remainder of the insect. The wings are long and slender and in most cases of a dull appearance.

Head.—(fig. 3F) This is structurally similar to that of *Swammerdamella* (Cook, 1956, fig. 6H). There are three ocelli with the lateral ocelli almost twice the diameter of the median ocellus. The eyes are holoptic in both sexes, are beset with short setae, and occupy the anterior one-third of the head capsule. The antennae are 9- to 10-segmented. They are 9-segmented in the known females of the *Brunnescens* group and 10-segmented in males and females of all other species. The head is convex behind the eyes and bears scattered setae. The tentorium is complete and arises posteriorly in the premaxillary suture.

The mouth parts are as those in the previously described genera. The rostrum length is variable, but the labellae are in general small. The maxillary palpi are single-segmented, rather slipper-shaped, and beset with numerous setae and sensory hairs. The cardo-stipites are partially sclerotized but without setae.

Thorax.—The thorax (fig. 5G) is well sclerotized, laterally compressed, and considerably elongated when compared with that of the previously described genera. The anterior spiracle is in the dorsal half of the anterior anepisternum and not on a separate, triangular, spiracular plate. Supra-alar setae are not conspicuous in most species. All of the sclerites of the thorax bear at least a few small setae, unlike the genera previously described. The post-notal phragma is long as in other genera.

The wings (fig. 3G) are dull owing to the presence of numerous microtrichia. Macrosetae are present on all wing veins (except on An in the *Scatopsiformis* group) and on the membrane from R_5 or M posteriorly. Section 2 of the costal margin of the wing is long—always exceeding the length of section 3. R and its branches are sclerotized and pigmented. Vein M_1 is interrupted at the base in most species. However, in *P. brunnescens* and *P. forcipata* a faint connection with M is sometimes evident. In *P. brevipennis*, the whole of M_1 is missing. Vein M_2 is nearly straight throughout its length; vein Cu_1 is straight except for a curve near the apex; vein Cu_2 is slightly bowed near or just before the middle. There is no apparent fold in the wing membrane between M_2 and Cu_1. There is a fold present, but this lies immediately anterior to Cu_1 and is not, therefore, apparent as a distinct entity. Vein An is usually present in the *Brunnescens* group but absent or inconspicuous in the *Scatopsiformis* group.

The pedicel of the halter is without setae, but the capitulum bears a few small setae. The whole structure is covered with microtrichia.

The prothoracic coxae are long and slender, nearly as long as the prothoracic femora. All

coxae and femora are sparsely setaceous. The tibiae and tarsi are more heavily setaceous.

In the *Scatopsiformis* group, the tibiae and tarsi are partly armed with very stout, short, spine-like setae (fig. 2F, G). This is not true of the *Brunnescens* group. The claws are large and simple, and there is a membranous, setaceous empodium.

Abdomen.—There are seven pregenital abdominal segments. The terga and sterna of segments 3 to 6 are generally narrow and bear scattered macrosetae but no microtrichia. Tergum 1 is wider than long, and tergum 2 is composed of 2 tergites. The membrane is longitudinally ribbed and beset with macrosetae. There are 7 to 8 pairs of spiracles in both sexes, depending on the species.

Male genitalia.—The genitalia (figs. 1A-F, 2A-E, and 3A-E) are complex in structure. There are two clearly defined types. In the typical *Brunnescens* group (figs. 1A-F, 2A) tergum 8 is large and bears a pair of spiracles in all species. Segment 9 is either reduced or is involved in the infolded, sclerotized, supporting structure of the vesica which is here connected intimately with the external genitalic complex. The gonocoxites are variously modified but obviously homologous in each of the species. These articulate with the internal supporting structures of the vesica. There is no obvious penis, and the gonapore cannot be located in any of the specimens available.

In the *Scatopsiformis* group (figs. 2B-E, 3A-E) tergum 8 is developed only in *P. rossi* (fig. 3D, E). Sternum 8 and all of segment 9 are fused and infolded to make up the supporting structure of the vesica. The gonocoxites are variously modified and are fused to the infolded vesica-supporting complex.

Female genitalia.—The structures of the female genitalia also serve to separate the *Brunnescens* and *Scatopsiformis* groups. In the *Brunnescens* group (fig. 4A-F) tergum 8 is simple, and in at least three of the species, *P. brunnescens* (fig. 4A), *P. forcipata* (fig. 4F), and *P. stonei* (fig. 4B), bears a pair of spiracles. Sternum 8 is divided into two small lobes in *P. brunnescens* (fig. 4A), a narrow band in *P. brevicornis* (fig. 4C, E) and is entirely unsclerotized in *P. forcipata* (fig. 4F). In the *Brunnescens* group there is a single spherical spermatheca (fig. 4C). In the *Scatopsiformis* group (fig. 5A-F) the tergum and sternum of segment 7 are drawn out posteriorly into paired lobes. In *P. serrata* (fig. 5D) and *P. scatopsiformis* (fig. 5E) there is a pair of slender appendages arising from the outer margins of tergum 7. Tergum 8 in this group is reduced to a small median lobe. Sternum 8 is also reduced in size. The single spermatheca in the *Scatopsiformis* group is elongate rather than spherical (figs. 4H, 5B, C, F).

In both groups there is a median sclerotized duct that opens on a small papilla in the atrial cavity (fig. 4A, F). This duct could not be traced but would seem to be the duct of an accessory gland of an unknown function.

Species Included in *Psectrosciara*

Brunnescens group: *P. brunnescens* (Brunetti) ♂, ♀, Ceylon, Seychelles Is.; *P. luzonensis* Edwards ♂, Philippine Is.; *P. brevicornis* Johannsen ♀, Guam; *P. forcipata* n. sp. ♂♂, ♀, California; *P. discata* n. sp. ♂♂, California; *P. oregonensis* n. sp. ♂♂, Oregon; *P. bakeri* n. sp. ♂, California; *P. brevistylis* n. sp. ♂, Iran; *P. stonei* n. sp. ♀♀, Texas.

Scatopsiformis group: *P. scatopsiformis* Enderlein ♂♂, ♀, Panama, Costa Rica; *P. californica* (Cole) ♂♂, ♀♀, Southwestern U. S., Mexico; *P. elongata* n. sp. ♂, Texas; *P. brevipennis* n. sp. ♂♂, California; *P. serrata* n. sp. ♀, Texas; *P. rossi* n.sp. ♂♂, Chile; *P. jamaicensis* n. sp. ♀, Jamaica.

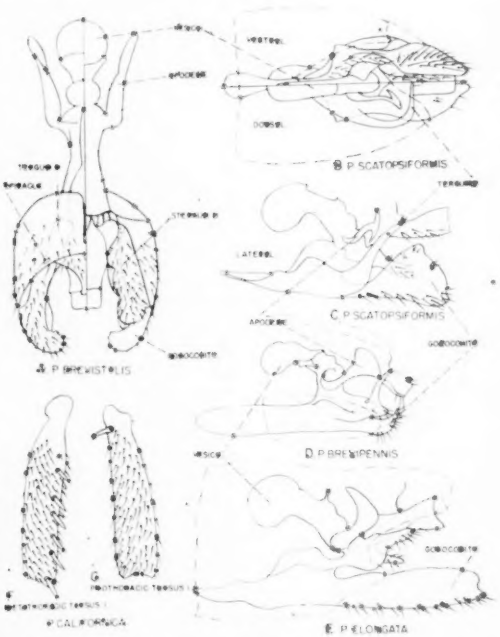

Fig. 2.—A-E, Male genitalia of *Psectrosciara* species; F, Metathoracic tarsus 1 of *P. californica*; G, Prothoracic tarsus 1 of *P. californica*.

This genus can be readily separated from the previously described genera in this family by the following external characters: Wings with macrosetae on all veins (except An in the *Scatopsiformis* group); membrane posterior to M or Cu_1 with macrosetae; anterior coxae extremely long, nearly as long as anterior femora; and anterior spiracle not on a separate spiracular sclerite.

KEY TO THE KNOWN NORTH AMERICAN SPECIES OF *PSECTROSCIARA*

MALES

1. Apex of tibiae and tarsal segments with stout setae (fig. 2F, G) 3
1a. Apex of tibiae and tarsal segments without stout setae 2
2. Median prolongation of tergum 8 without a terminal disc-shaped structure (figs. 1C, E) 3
2a. Median prolongation of tergum 8 with a disc-shaped structure (figs. 1B, F) 4
3. Gonocoxites stout, falciform (fig. 1C) ..... **forcipata**
3a. Gonocoxites slender, only slightly curved (fig. 1E) **bakeri**
4. Disc of posterior prolongation of tergum 8 with 4 setae; gonocoxites without large basal lobes; gonocoxites only slightly incurved (fig. 1B) **discata**
4a. Disc of posterior prolongation of tergum 8 with numerous setae; gonocoxite with large basal lobe; gonocoxite strongly curved, digitiform (fig. 1F) ..... **oregonensis**
5. Wings short, not projecting beyond apex of abdomen (fig. 5H); gonocoxites very short (fig. 2D) **brevipennis**
5a. Wings longer, projecting beyond apex or at least to abdominal apex 6
6. Gonocoxites elongate, not expanded apically (fig. 2E) ..... **elongata**
6a. Gonocoxites apically expanded (fig. 3A, B, C) **californica**

FEMALES

1. Apex of tibiae and tarsal segments with stout setae (fig. 2F, G) 3
1a. Apex of tibiae and tarsal segments without stout setae 2
2. Tergum 7 with a pair of acute posterior projections (fig. 4I); tergum 9 terminal (fig. 4F) ..... **forcipata**
2a. Tergum 7 with a pair of short, rounded posterior processes (fig. 4B); tergum 8 terminal, (fig. 4B) **stonei**
3 A pair of slender, finger-like appendages on ventral margin of tergum 7 (fig. 5D); spermatheca ovoid (fig. 5B) ..... **serrata**
3a. No finger-like appendages on ventral margin of tergum 7 (fig. 5A); spermatheca elongate (fig. 5C) ..... **californica**

Psectrosciara brunnescens (Brunetti)

Scatopse brunnescens Brunetti, June 7, 1911. Rec. Indian Mus. 4: 281.
Psectrosciara mahensis Kieffer, 1911. *in* Enderlein, Arch. Naturgesch. 77, 1, Suppl. 3, p. 192. [*Nomen nudum*]
P. mahensis Kieffer, 1912. *in* Enderlein, Trans. Linn. Soc. London, Zool. 15, pp. 192–3.
P. mahensis Kieffer, Enderlein, 1912, Zool. Anz. 40: 280.
P. brunnescens (Brunetti), Edwards, 1927, Spolia Zeylanica 14: 120.

Type of *P. brunnescens* in Indian Museum; type of *P. mahensis* in British Museum (Natural History).

Male.—Total length 1.48 mm. Color light greyish brown with lighter golden brown setae. Anterior tibiae and tarsi somewhat darker in color. Halteres brown. The pale color here is probably due to fading since Kieffer's and Brunetti's descriptions both indicate a dark brown to nearly black color. Maxillary palpi .08 mm. long. Labellae small, rostrum short. Enlarged supra-alar setae 3, subspiraculars 4.

Wings (fig. 3G) clear, 1.58 mm. long. All veins clearly marked, M_1 incomplete or faint at base. An present. Macrosetae present on all veins, also on membrane at tip of wing posterior to R_2 and M_1 and scattered behind Cu_1. Wing membrane covered with microtrichia.

Genitalia as in fig. 1A, gonocoxites small, mandible-like.

Females.—Total length 1.37–1.45 mm.; wing length 1.48 mm. Antennae with nine segments, head as in fig. 3F. Supra-alar setae 4, subspiraculars 3. Otherwise as male in color and chaetotaxy. Genitalia as in fig. 4A.

Comments.—The type locality of this species is Peradeniya, Ceylon. Kieffer's specimens are from Mahe, Seychelles Islands.

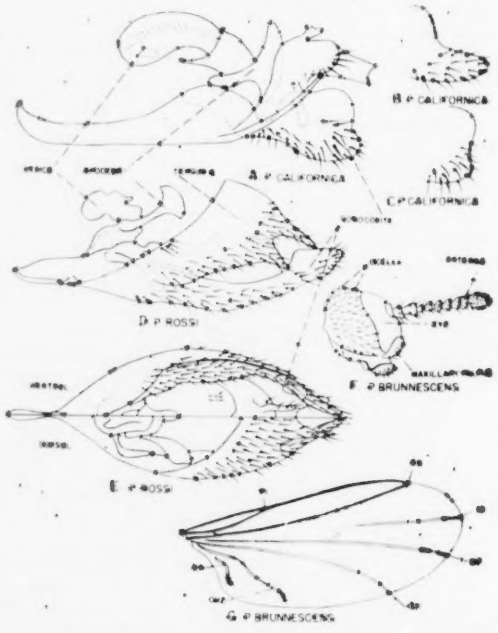

FIG. 3.—A–E, Male genitalia of *Psectrosciara* species. F, Head of female *P. brunnescens*; G, Wing of *P. brunnescens*.

Specimens examined.—1 ♂, 2 ♀ ♀, Sudaganga, Ceylon, July 17–18, 1922, Senior-White. (BM 1924–100).

Psectrosciara luzonensis Edwards

Psectrosciara luzonensis Edwards, 1929. Notulae Entomologicae 9: 80.

Male.—Total length approximately 1.8–2.00 mm. Color very dark brown, wings with veins distinct, vein M_1 interrupted at base. Genitalia as in fig. 1D.

Female.—Not seen.

Comments.—This species is known only from the holotype ♂ and a ♀ which are deposited in the Zoological Museum of the University, Hel-

sinki. The holotype is shrunken, and the wings are distorted; the antennae are missing, and the genitalia are mounted in a drop of balsam on a plastic point with the specimen. The structures of the genitalia are sufficient to identify the species and to permit it to be assigned to the *Brunnescens* group.

Specimen examined.—Holotype ♂, Lamao, Luzon, VII, 1914. (Mus. Helsinki No. 2141).

Psectrosciara brevicornis Johannsen

P. brevicornis Johannsen, 1946. Insects of Guam II. Bernice P. Bishop Museum Bulletin 189, p. 188.

Male.—Unknown.

Female.—"Head and thorax black, subshining; antennae . . . nine segmented . . . Abdomen black, subshining becoming more brownish posteriorly, pubescent. Wings [1.10–1.14 mm. long] clear, radial veins blackish, the other veins colorless . . . subcosta and anal vein delicate, the others sharply defined; base and tip of anterior branch of media [M_1], distinct though somewhat weak . . . microtrichia coarse, macrotrichia lacking in the costal cell and basal part of the radial cell, elsewhere, including on the veins, sparsely but well distributed. Halteres dark. Legs more or less yellowish brown; strong. . . . Length 1.6 mm."

Genitalia as in fig. 4D, E.

Comments.—The above description is from Johannsen's original, except for the illustration of the genitalia. The holotype is slide-mounted so as to be extremely obscure and structures cannot be measured. The dorsal-ventral view in the figure was reconstructed from the rather badly distorted lateral aspect available on the slide. Affinity with the *Brunnescens* group is clear from the structure of the genitalia, the spherical spermatheca, and the nine-segmented antennae.

Specimens examined.—Holotype, ♀, Umatac, Guam, V. 28–36, O. H. Swezey, CU No. 2390; paratype ♀ (slide & alcohol, dissected), Piti, Guam, 7–21–36, CU No. 2390.

Psectrosciara brevistylis, new species

Male.—Total length 3.10 mm. This specimen was in alcohol, and the color cannot therefore be described except to note that the head and the prothoracic tibiae and tarsi are darker than the remainder of the insect. Antennae 10-segmented. Maxillary palpi .10 mm. long; rostrum short. Supra-alar setae 4; subspiraculars 3. Legs with stout setae at apex of tibiae and on the first and second segments of the meso- and metathoracic tarsi.

Wings missing in the only available specimen.

Genitalia as in fig. 2A. Tergum 8 with a small, triangular, posterior process; gonocoxites short, stout and incurved at apex.

Female.—Unknown.

Specimen examined.—*Holotype:* ♂, Adaban, Iran, April 22, 1951, E. J. Hambleton. Holotype deposited in the U. S. National Museum collections.

Psectrosciara forcipata, new species

Males.—Total length 2.68–3.28 mm. Color dark brownish black, subshining; head jet black, shining; apex of abdomen paler brown; setae pale; antennae dull black with silvery pubescence; legs concolorous with body; wings brownish, dull; halteres grey-brown. Antennae 10-segmented. Maxillary palpi .12–.13 mm. long, more slender than in *Scatopse*; rostrum short. No distinctive supra-alar seta row; 12–14 subspiracular setae. Legs with enlarged setae only at apex of tibiae.

Wings pale brownish, 2.96–3.28 mm. long; much like fig. 3G. R_1 and R_3 pigmented, posterior veins conspicuous but not pigmented; base of M_1 faint or absent. An present as well as Sc. Macrosetae on all veins and on membrane at wing apex posterior to R_3 and sparsely covering membrane behind Cu_1. Whole wing surface covered with microtrichia.

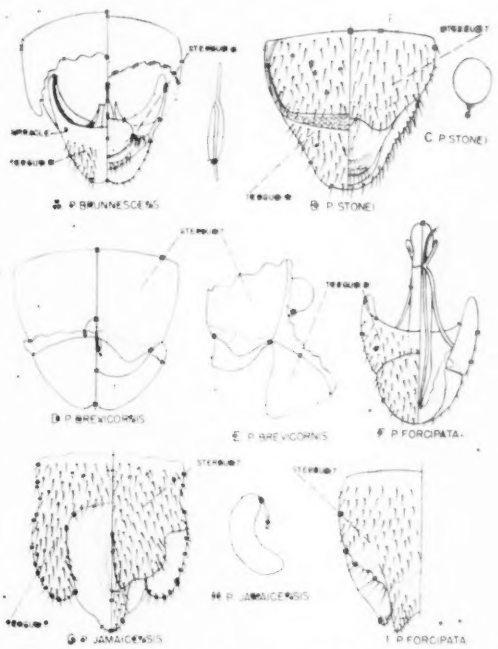

FIG. 4.—A, B, D, E, F, G, Female genitalia of *Psectrosciara* species; C, H, Spermathecae of *Psectrosciara* species; I, Sternum 7 of *P. forcipata*.

Genitalia as in fig. 1C. Tergum 8 with a slender, darkly pigmented, apically truncate process. Gonocoxites falciform at apex.

Female.—Total length approximately 2.8 mm.; wing length 2.96 mm. Wing similar to male; base of M_1 faint but present, a few macrosetae anterior to Cu_1. Otherwise like male in color and chaetotaxy. Sternum 7 of abdomen bifurcate at apex (fig. 4I). Genitalia as in fig. 4F. Spiracles present on tergum 8; spermatheca spherical.

Known only from Berkeley, California.

Specimens examined.—Holotype: ♂, Berkeley, California, April 17, 1948, W. W. Wirth. Allotype: ♀, Berkeley, May 7, 1915, M. C. Van Duzee. Holotype in the U. S. National Museum. Allotype in the California Academy of Sciences. Paratypes: 5♂♂, Berkeley, April 17, 1948; 8♂♂, April 25, 1948 (ex Umbelliferae); 1♂, May 17, 1937; 1♂, May 7, 1915; 1♂, May 24, 1915.

Psectrosciarà discata, new species

Males.—Total length 3.10–3.55 mm. (Alcoholic specimens). Color as in *P. forcipata* except anterior tarsi darker than posterior tarsi. Antennae 10-segmented. Maxillary palpi .09–.10 mm. long; rostrum short. No distinctive supra-alar setae; subspiraculars 4–8. Generally with setae more sparse than in *P. forcipata*. Legs with enlarged setae only at apex of tibiae and on first tarsal segment of metathoracic legs.

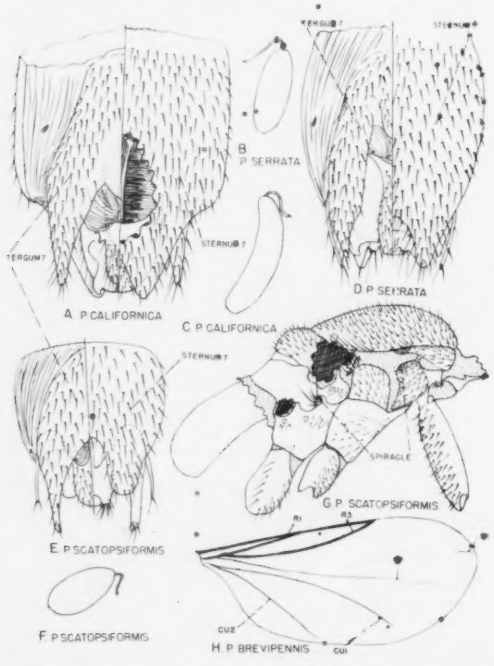

FIG. 5.—A, D, E, Female genitalia of *Psectrosciara* species; B, C, F, Spermathecae of *Psectrosciara* species; G, Thorax of *P. scatopsiformis*; H, Wing of *P. brevipennis*.

Wings pale brownish, dull; 2.24–2.42 mm. long. Venation as in *P. forcipata* except veins posterior to R_3 faint and macrosetae largely confined to veins and membrane posterior to Cu_1.

Genitalia as in fig. 1B. Tergum 8 with a slender posteriorly directed process expanded at apex into a disc-shaped structure. Gonocoxite slender, not falciform.

Female.—Unknown.

Comments.—This species is close to *forcipata* but differs in the smaller maxillary palpi, smaller number of subspiracular setae, less conspicuous posterior wing veins and in genitalic structure.

Specimens examined.—Holotype: ♂, Auburn, Placer Co., California, May 26, 1950, L. W. Quate (Citronella bait trap). Type in the University of Nebraska collection. Paratypes: 3♂♂, same date as holotype.

Psectrosciara oregonensis, new species

Males.—Total length 2.24 mm. Color dark brownish black, subshining; head black, shining; setae all pale; antennae dull black with silvery pubescence; legs concolorous with body; wings colorless; halteres greyish brown. Antennae 10-segmented. Maxillary palpi .11 to .12 mm. long; rostrum short. No distinctive supra-alar setae; subspiraculars 5–7. Legs with enlarged setae only at apex of tibiae.

Wings clear, colorless, 2.73 mm. long. Venation like *P. discata*. Veins posterior to R_3 very faint, marked chiefly by setae; base of M_1 lacking; macrosetae on all veins, at apex of wing behind R_3, on membrane behind Cu_1 and at apex behind M_2. Wing surface covered with microtrichia.

Genitalia as in fig. 1F. Posterior process of tergum 8 similar to that of *P. discata* but quite setaeous. Gonocoxites digitiform.

Females.—Unknown.

Comments.—This species is very similar to *P. discata* but differs in the structure of the male genitalia.

Specimens examined.—Holotype: ♂, Dever, Oregon, May 18, 1931. Holotype in the Oregon State College collections. Paratypes: 1♂, same data as above; 1♂, Corvallis, Oregon, June 3, 1935.

Psectrosciara bakeri, new species

Male.—Total length 3.10 mm. Color very dark brown to nearly black, subshining; head slightly darker, shining; setae pale; antennae dull black with silvery pubescence; legs concolorous with body. Antennae 10-segmented. Maxillary palpi .10 mm. long; rostrum short. Four somewhat enlarged supra-alar setae; subspiraculars 10. Legs with enlarged setae only at apex of tibiae.

Wings faintly brownish, dull; 2.34 mm. long; venation and chaetotaxy as in preceding species. Posterior veins distinct as in *P. forcipata*; base of M_1 absent.

Genitalia as in fig. 1E. Tergum 8 with a short posterior process; gonocoxites slender, slightly incurved.

Females.—Unknown.

Specimen examined.—Holotype: ♂, Claremont, California. Baker (no other data). Holotype deposited in the U. S. National Museum collection.

Psectrosciara stonei, new species

Males.—Unknown.

Females.—Total length 1.34 mm. Unicolorous, light greyish brown except anterior tibiae and tarsi slightly darker (specimens in alcohol). Antennae 9-segmented. Maxillary palpi .06 mm. long; rostrum very short, not projecting beyond maxillary palpi. Supra-alar setae 4; subspiraculars 5. Legs with enlarged setae only at apex of tibiae.

Wings clear, 1.00 mm. long. Posterior veins very weak, indicated only by faint fold and macroseta rows. Macrosetae sparsely distributed at wing apex and posterior to M_2; base of M_1 absent; microtrichia cover the whole wing surface. Sternum 7 of abdomen bilobed; genitalia as in fig. 4B. Spiracles present on tergum 8; tergum 9 absent; spermatheca spherical.

Specimens examined.—*Holotype:* ♀, Brownsville, Texas, July 12, 1956, reared from cotton bolls. Type in the U. S. National Museum collection. Paratypes: 2♀♀, Los Fresnos, Texas, July 13, 1956, reared from cotton bolls.

Psectrosciara scatopsiformis Enderlein

P. scatopsiformis Enderlein, 1912. Zoo. Anz. 40: 281.
P. scatopsiformis Enderlein. Melander, 1916, State Coll. Wash. Ag. Exp. Sta. Bull. 130, p. 16.
P. scatopsiformis Enderlein. Duda, 1928, Konowia 7: 200–203.

Males.—Total length 2.18–2.60 mm. Color dark brownish black, subshining; head jet black, shining; antennae dull black with silvery pubescence; setae all pale; legs concolorous with body; halteres dark grey. Antennae 10-segmented. Maxillary palpi .10 mm. long. Rostrum longer than in *Brunnescens* group, nearly one-third of total head height. No distinct supra-alar seta row; 3 to 6 subspiraculars. Legs with enlarged setae on apex of tibiae and also on tarsi (as in fig. 2F); first segment of prothoracic tarsi with a regular comb-like row of spines on the posterior margin in addition to several irregular rows of spines on the posterior and inner surfaces; prothoracic femora and tibiae considerably enlarged, making the legs appear prehensile.

Wings clear, colorless, 1.80–1.96 mm. long. Venation as in fig. 3G; R_1 and R_3 dark grey; posterior veins very faint; base of M_1 absent; macrosetae on all veins except An, also on membrane at wing apex and behind M_2. Microtrichia very coarse.

Genitalia as in fig. 2B, C. Segments 8 and 9 seemingly entirely invaginated and much reduced to form the internal supporting elements of the vesica. Gonocoxite with a slender base, apically widened.

Female.—Total length 2.68 mm.; wing length 1.83–2.20 mm.; color dark brown, considerably paler than males. Otherwise like male in structure and chaetotaxy. Genitalia as in fig. 3E, F. Tergum and sternum 7 drawn into paired, posteriorly directed processes; a pair of accessory finger-like processes at the lateral margins of tergum 7; spermatheca ovoid.

Comments.—The specimens available are somewhat smaller than the single female from which Enderlein described the species. The type locality is Costa Rica, and the type is supposedly in Stettin. I have had available three specimens from San José, Costa Rica, collected by H. Schimdt who also collected the holotype of the species.

Specimens examined.—2♂♂, Espino, PANAMA, Sept. 18, 1952; 3♂♂, Garachine, Feb. 1953; 1♂, Tocumen, Jan. 1953; 1♂, Mar. 1953; 1♂, Paris, Oct. 23, 1952; 7♂♂, Patino Pt., July 12–13, 1952; 1♂, July 21; 1♂, Aug. 2; 1♂, Aug. 17, 1952; 1♂, Chorrera, Sept. 8, 1952; 1♂, Pt. Mensabe, Los Santos Prov., Oct. 22, 1952; 2♂♂, 1♀, San Jose, COSTA RICA, V:15:VII [*sic*], H. Schmidt; 1♀, Turrialba, Aug. 1920; 5♂♂, La Caja, 8 km. W. San José, 1930, H. Schmidt.

Psectrosciara californica (Cole)

Sciatopse californica Cole, 1912. First annual Report of the Laguna Marine Laboratory, Pomona College, pp. 150–151.
Psectrosciara californica (Cole). Melander, 1916, State Coll. Wash. Ag. Exp. Sta. Bull. 130, pp. 16–17.
Psectrosciara californica (Cole). Duda, 1928, Konowia, 7: 208.
Psectrosciara scatopsiformis mexicana Duda, 1928, Konowia, 7: 204.

Males.—Total length 2.17–2.76 mm. Color dark brownish black, somewhat shining; head jet black, shining; antennae dull black with silvery pubescence; setae all pale, legs concolorous with body except apical two-thirds of prothoracic tibiae and tarsi darker. Wings clear, colorless to slightly infuscated; halteres dark grey; abdomen generally yellowish grey to dull black except for shining middorsal line. Antennae 10-segmented. Maxillary palpi .11–.12 mm. long; rostrum nearly one-third of total head height. No distinct supra-alar seta row; 7 to 10 subspiraculars. Legs with enlarged setae at apex of tibiae and also on tarsi (fig. 2F, G). First tarsal segment of prothoracic legs with spines in addition to setae but no regular comb-like row except in one specimen from Córdoba, Mexico. Prothoracic legs appear prehensile. Wings 2.08–2.66 mm. long. Venation as in fig. 3G; R_1 and R_3 dark; posterior veins very faint; macrosetae on all veins except An and on membrane everywhere behind R_3, more dense behind Cu_1; M_1 with base absent; microtrichia covering whole of membrane.

Genitalia as in fig. 3A, B, C; similar to *P. scatopsiformis*. Gonocoxites showing some variation. Fig. 3A that of specimens from California and Sedona, Arizona; fig. 3B that of a ♂ from the Baboquivari Mts., Arizona; and fig. 3C that of a ♂ from Cordoba, Mexico.

Females.—Total length 2.06–2.54 mm.; wing

length 2.00–2.18 mm. Color, chaetotaxy, and structure as in males. Wing as in males, but posterior veins are somewhat more conspicuous. Genitalia as in fig. 5A. Tergum and sternum 7 drawn into paired processes posteriorly; no accessory finger-like processes at margins of tergite 7; spermatheca elongate (fig. 5C).

Comments.—There is some variation apparent in this species which has a rather wide southwestern distribution. Specimens from southern California and Sedona, Arizona, are essentially identical in structure in both the males and females. A single male from the Baboquivari Mountains is like the California male in all characters except for the ventral prolongation of the gonocoxites (fig. 3B). A male and female from Córdoba, Mexico, are also considered to be this species, although they are somewhat distinctive. The female from Córdoba cannot be distinguished from the female from California or Arizona. The male has somewhat differently formed gonocoxites and also has a conspicuous comb-like row of spines on tarsus 1 of the prothoracic legs. Possibly this might be treated as a subspecies, but since there are no differences apparent in the female it seems best to merely include it as a variant of *P. californica*.

Specimens examined.—1 ♀, Laguna Beach, California, Baker; 1 ♂, Cajon, California, June 28, 1945; 1 ♂, 2 ♀ ♀, Sedona, Arizona, June 20, 1938; 1 ♂, Baboquivari Mts., Arizona, Aug. 10, 1924; 1 ♂, 1 ♀, Córdoba, Mexico, March 25, 1908.

Psectrosciara elongata, new species

Male.—Total length 2.92 mm. Color dark brownish black, somewhat shining; head jet black, shining; terminal abdominal segment black, shining; abdomen largely black, dull; legs concolorous with rest of body, except apical two-thirds of tibiae and tarsi of anterior legs darker. Wings faintly infuscated, dull. Antennae 10-segmented. No distinct supra-alar seta row; subspiraculars 6. Legs with enlarged setae at apex of tibiae and also on tarsi. First tarsal segment of prothoracic legs with a regular comb-like row of spines on the posterior margin in addition to several irregular rows on the posterior and inner surfaces. Prothoracic legs prehensile in appearance.

Wings 2.17 mm. long. Wing venation typical for group except posterior veins more clearly marked than in *P. californica*. Macrosetae on all veins (except An) and on whole of membrane posterior to R_3; microtrichia coarse, covering membrane.

Genitalia as in fig. 2E. Gonocoxites equally wide throughout length, apically emarginate, sparsely setaceous, extending beyond apex of segment 7.

Female.—Unknown (see *P. serrata*).

Specimen examined.—*Holotype:* ♂, San Antonio, Texas, April 8, 1907, F. C. Pratt, collector. Type in the U. S. National Museum.

Psectrosciara brevipennis, new species

Males.—Total length 2.20–2.26 mm. Color dark brownish black, somewhat shining; head jet black, shining; posterior abdominal segment dark, subshining; abdomen otherwise dull black. Legs all concolorous with general body color. Wings colorless; halteres dark grey. Antennae 10-segmented. Only 2 ocelli present. Maxillary palpi .07 mm. long; rostrum about one-third of total head height. No distinct supra-alar seta row; subspiraculars 4. Legs with enlarged setae at apex of tibiae and also on tarsi, a few spines on posterior face of tarsus 1 of prothoracic leg but no regular comb-like row.

Wings (fig. 5H) very short, 1.13–1.20 mm. long, venation reduced; M_1 only present near wing margin; macrosetae small, present on veins C, R_1, R_3, base of M, Cu_1 and Cu_2, sparsely present on membrane; microtrichia fine and relatively sparse.

Genitalia as in fig. 2D. Gonocoxites very short, curved dorsad apically.

Female.—Unknown.

Specimens examined.—*Holotype:* ♂, El Centro, California, June 27, 1917, J. M. Aldrich, collector. Holotype in the U. S. National Museum. Paratype: ♂, Lindsay, California, Aug. 1, 1911, Cantaloupe blossom.

Psectrosciara serrata, new species

Males.—Unknown.

Females.—Total length 2.14–2.76 mm. Color grey-brown; head darker, nearly black; legs concolorous with body except basal one-third of tibiae and tarsi of prothoracic legs nearly black; wings slightly infuscated; halteres dark grey; all setae pale (specimens in alcohol). Antennae 10-segmented. Maxillary palpi .09–.10 mm. long; rostrum nearly one-third of total head height; three ocelli present, the median ocellus less than one-half the diameter of the lateral ocelli. No distinct supra-alar row of setae; subspiraculars 8. Legs with enlarged setae on apex of tibiae and on tarsi; first segment of prothoracic tarsi with a regular comb-like row of spines on the posterior margin in addition to several irregular rows on the posterior and inner surfaces. Prothoracic femora and tibiae enlarged as to appear prehensile.

Wings 1.79–1.97 mm. long; venation typical for the group; base of M_1 absent; posterior veins not pigmented but clearly apparent; macrosetae on all veins except An and on membrane everywhere posterior to R_3; microtrichia rather coarse.

Genitalia as in fig. 5B, D. Tergum and sternum 7 both drawn out into paired, posteriorly directed processes; paired accessory finger-like processes articulating to the lateral margins of tergum 7 as in *P. scatopsiformis*; spermatheca ovoid (fig. 5B).

Comments.—This species is very like *P. elongata* in general appearance and chaetatoxy and may well be the female of that species. It seems preferable, however, to risk the creation of a synonym

rather than associating two distinct species under the same name on such tenuous evidence as general resemblance.

Specimens examined.—*Holotype:* ♀, Los Fresnos, Texas, July 13, 1956, reared *ex* cotton bolls. Type in the U. S. National Museum Collection. Paratypes: 1♀, same data as holotype; 1♀, Los Fresnos, July 13, 1956, *ex* cotton bolls; 1♀, Olmito, Texas, July 16, 1956, *ex* cotton boll; 1♀, *trans* Mexico at Brownsville, Texas, March 24, 1937, *ex* Easter lilies.

Psectrosciara rossi, new species

Males.—Total length 3.31–3.80 mm. Color very dark brownish black, somewhat shining; abdomen somewhat paler, more brown; legs concolorous with body; wings faintly brownish; halteres dark grey-brown; antennae 10-segmented. Maxillary palpi .15 to .17 mm. long; rostrum nearly one-third of total head height. No sharply defined supra-alar seta row; sub-spiraculars 7. Legs with enlarged setae on apex of tibiae and on tarsi; no spines on tarsi. Prothoracic femora and tibiae not conspicuously enlarged, forelegs not prehensile in appearance.

Wings 2.48 to 2.96 mm. long; venation similar to that in fig. 3G except posterior veins extremely faint and An apparently absent; base of M_1 absent. Macrosetae on all veins and on membrane posterior to R_5; membrane covered with microtrichia.

Genitalia as in fig. 3D, E. Tergum 8 present and well developed, drawn into two pairs of posteriorly directed processes; gonocoxites very long and setaceous.

Females.—Unknown.

Specimens examined.—*Holotype:* ♂, Coquimbo Prov. Chile, 5 mi. N. Laguna Dam, 8000 ft. elev., December 6, 1950, Ross & Michelbacher. Type in the collection of the California Academy of Sciences. Paratypes: 5♂♂, same data as holotype.

Psectrosciara jamaicensis, new species

Male.—Unknown.

Female.—Total length 2.08 mm. Color generally pale yellowish-grey; head and thorax light brown, somewhat shining; abdominal segments dull grey, darker than intersegmental membrane; antennae dull grey; halteres light grey; wings slightly infuscated; legs concolorous with body except basal one-third of anterior tibiae and anterior tarsi darker; all setae pale. Antennae 10-segmented. Maxillary palpi .07 mm. long; rostrum approximately one-fourth total head height. No supra-alar seta row; subspiraculars 5. Legs with enlarged setae at apex of tibiae and on tarsi; some spines on prothoracic tarsus 1 but no regular comb-like row. Prothoracic femora and tibiae somewhat enlarged, appearing more or less prehensile.

Wings 1.34 mm. long; posterior veins faint; R_5 terminates slightly beyond the middle of the wing; macrosetae small and very sparsely distributed; microtrichia small.

Genitalia as in fig. 4G. Tergum 7 produced into two widely separated, rounded lobes; sternum 7 cleft medially; spermatheca (fig. 4H) elongate.

Specimen examined.—*Holotype:* ♀, Ocho Rios, Jamaica, Sta. 373, February 2, 1937, Chapin and Blackwelder. Type in the U. S. National Museum Collection.

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NOTICE TO MEMBERS

A new periodical, MISCELLANEOUS PUBLICATIONS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA will be initiated by the Society in 1959. It will be devoted to entomological articles of more than 20 printed pages and of a type and length less than that suitable for the Thomas Say Foundation series.

If you have questions or a suitable manuscript please write the Executive Secretary, Entomological Society of America, 1530 P Street, N. W., Washington 5, D. C.

COLONIZATION OF THE FLOODWATER MOSQUITO, PSOROPHORA HOWARDII COQ. (DIPTERA: CULICIDAE)[1]

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ABSTRACT

Methods for hatching the eggs, rearing the larvae, and maintaining the adults were developed which permitted carrying a cage colony of this species through seven successive generations. Males sought out females not in flight and mated with them even in very close confinement. Eggs require 6 to 7 days for incubation at 25°, and hatch readily in media that reduced the level of dissolved oxygen; in practice, cultures of wild bacteria growing in nutrient broth effectively hatched a high percentage of eggs. Larvae mature in about 5 days, and completion of an entire generation within 26 days was possible. First-instar larvae are filter-feeders, the later instars are predaceous and could be fed on other mosquitoes, on other small arthropods, and in some cases on brine shrimp. Adults are relatively short-lived, the males living up to 1 week, females normally about 3 weeks but sometimes as long as 5 weeks. Females generally laid from 70 to 100 eggs each, but an occasional female deposited 250 eggs or more.

Colonization of mosquitoes is desirable in order to determine many details of their bionomics. Unfortunately very few species lend themselves to being kept in cages. *Psorophora howardii* Coq. one of the largest of the floodwater species is readily adaptable to cages. Methods of hatching the eggs, rearing the larvae and maintaining the adults were developed enabling one to carry the species through successive generations in the laboratory. Observations on the developmental stages under laboratory conditions and reactions of the adults to caged conditions are reported herein.

METHODS

Eggs of *P. howardii*, like those of other floodwater mosquitoes, may be hatched in any media that will progressively reduce the level of dissolved oxygen (Borg and Horsfall, 1953). For the purpose of this work all hatching was carried out in the unsterilized solutions of nutrient broth made up in tap water. Eggs were transferred directly from a moist chamber to freshly prepared hatching medium in shell vials. The vials were stoppered so that no air spaces formed above them. Within a few hours all eggs were hatched. When the oxygen level is lowered by means of replacement with nitrogen (Horsfall et al., 1958) the prehatching interval may be greatly shortened.

Newly hatched larvae may be kept in a common container in tap water. Nothing need be added because the larvae in the first instar will molt without feeding on any visible particulate matter. However, larvae in this instar will feed on yeast and suspensions of dog biscuit when offered to them.

After the first molt, larvae are best reared separately in order to prevent cannibalism. Stender dishes or finger bowls make suitable cages for individual rearing. Larvae in the last three instars are predatory principally on smaller insects such as associated species of mosquitoes. For this work they were maintained on a diet consisting of larvae of *Aedes vexans*, *A. aegypti* and *Culex* spp. Because of the ease of maintaining a colony of *A. aegypti*, the bulk of the diet consisted of larvae of this species. Larvae of *A. vexans* and *Culex* were often collected from the field when they were abundant during the summer months. In employing larvae of *A. aegypti* for food, an egg supply of this species was kept on hand and hatched whenever the larvae of *P. howardii* in the first instar molted into the second instar. The size of newly hatched larvae of *A. aegypti* was ideal since the predaceous larvae had no difficulty in feeding. Once the predaceous larvae attained the fourth instar they fed easily on larger larvae of the other species. To prevent the overcrowding of larvae in the rearing dishes, food was introduced several times a day into the containers with the predaceous larvae.

Table 1.—Interval for development of embryos of *P. howardii* at 25° C. in the laboratory

Interval Days	Number of Eggs	Larvae hatched	
		Number	Percent
0-5	180	0	0
6	51	36	71
7	50	46	92
8	55	49	89

Following pupation in the rearing dishes, the pupae were transferred to dishes containing tap water which were placed in the cages housing the adults. A 2-inch square of 28-mesh plastic screen was used for carrying pupae from one dish to another. A piece of screen was advantageous in that the transfer was rapid with no danger of injury to the large pupae. The number in a

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single container was limited to approximately 50 pupae.

Adults were kept in cages of any convenient size. Usually cages 12 inches cube were used. Forty or more adults could be caged together in such a chamber. Mating took place readily even when a male and female were confined together in a test tube. Most rearing was done at a temperature of 25° C. The cages were kept in a chamber where the humidity was about 75 percent R.H. Higher humidity and water were available in the form of wet balls of cellucotton within the cages.

Males and females fed readily in captivity. Carbohydrate was provided as moist fruits or pledgets of cotton soaked in honey. Both human blood and pigeon blood would be taken when offered in the cages.

Eggs were collected on bits of moist cheesecloth. A pad of cheesecloth ½ to 1 inch thick was placed on a cover or bottom of a petri dish. The pad was kept moist during the interval which the females were ovipositing. Eggs deposited on cheesecloth were removed by immersing it in a pan full of water and agitating it until all eggs were free. The collected eggs were placed on moist filter paper and incubated at 25° C. Incubation for 6 days at 25° was necessary before the embryos were mature. Under these conditions eggs may be kept for months in the laboratory.

Table 2.—Rate of hatching of eggs of *P. howardii* in nutrient broth at a constant temperature of 25° C. in the laboratory

Dilution of broth in water	Eggs Used	Percent larvae hatched			Total	
	Number	0-3 hr.	4-6 hr.	7-10 hr.	Number	Percent
1:100	54	66	10	0	41	76
1:500	37	21	38	0	22	59
1:1000	35	31	2	30	22	63
1:2000	27	7	78	0	23	85
1:5000	50	0	48	46	47	94
None	30	0	0	0	0	0

HABITS

Incubation.—The embryo completes development in the manner comparable to that of other floodwater mosquitoes. The most favorable temperature was 25° C. At this temperature most embryos have completed development within 6 days. All are hatchable within 7 days (table 1). At a lower temperature of 20°C., development of embryos was markedly retarded. None was mature after 18 days of exposure. Some development had taken place since development was completed within 3 days after raising the temperature to 25° C. Following incubation, eggs of *P. howardii* were found to be viable for over a year when stored in a moist chamber at 22–25° C.

Conditioned eggs could be hatched by any of the standard methods for reducing the level of dissolved oxygen, but a slow drawdown of the oxygen yielded the greatest number of larvae. A dry nutrient broth when added to unsterilized water was the hatching medium of choice. Bacterial growth used up the oxygen within a few hours and provided a natural gradient in oxygen capable of stimulating embryos conditioned for hatching at any level of oxygen along the gradient. Media giving the highest percentage of hatch were those diluted at 1:2000 or more (table 2). More concentrated media caused hatching to begin earlier for the eggs that did hatch. The range of temperature over which hatching was constantly high is that between 22° and 35° C. (table 3). Contamination of the hatching medium at 20° by bacteria caused the oxygen level to be drawn down at a rate too fast for the activity of the embryo and no hatching took place. At temperatures around 40° C. the embryos were killed.

Embryos retained their viability for a year or more when kept in a moist chamber at 4° or 25° C. In this regard they were more durable than *Aedes vexans* (Horsfall et al., 1958). Exposure to 4° for several days had no retarding effect on hatchability (table 4). Eggs left 7 days at the low temperature hatched within a few hours when placed in fresh hatching medium at 25° C. In fact, no difference was observed in rate or percentage of hatch between eggs kept at low or "summer" temperatures and those kept at 4° C. Eggs of *A. vexans*, on the other hand, required 48 hours at 24° C. to stimulate a high percentage of hatch.

Larval feedings.—Two types of feeding are characteristic for the larvae of *P. howardii*. A larva in the first instar has normal mouth brushes and other mouth parts characteristic for the family. Larvae in this instar may feed by filtering in a manner common to many other larvae of mosquitoes. However, no intake of visible food particles was observed for this instar for its development. That such larvae may feed was demonstrated by placing some of them in a suspension of carmine. Tiny particles of carmine

were seen to be ingested, and within a few minutes traces of carmine had appeared in the digestive tract of each larva. Approximately an hour later the first of the carmine was egested.

Mouth parts of the second, third, and fourth instars are prehensile and are used for seizing and holding instead of acting as filters. The mouth brushes which were instrumental in feeding in the first instar come to be drawn under the frontal-lateral margins of the head. The mandibles are elongated and relatively enlarged. They appear to be the chief appendages for grasping any moving animal small enough to be seized, including a larva of its own kind. Larvae seldom retain hold of the prey which is appreciably larger in size than they.

Predaceous instars of this mosquito feed in a characteristic manner. Most prey is captured as it moves by the larva and within a distance less than the length of the body. The prey may be wriggling under the surface or gliding by at the surface. In the former instance the larva will strike by a sudden jerk of the anterior part of the body while opening the mandibles to impale the prey. Normally the prey is caught midway of the body or toward the caudal end. When a victim is sighted gliding near a larva the latter raises its body slowly to a position nearly horizontal with the surface, and the head is directed so as to intercept the passing prey. Again a snap of the body and the trap-like spring of the mandibles results in a meal. Once in a while a larva will glide slowly toward an intended victim that is disturbing the water by feeding. If the prey is large a larva may wrestle with its victim by rapidly wriggling along the bottom until the hold on the victim is secure. The prey is rapidly ingested by a kind of stuffing motion until only the head and air tube remain. These parts are usually discarded when older larvae are eaten. Larvae, especially younger ones, could be induced to ingest smaller crustaceans and even larger Protozoa. All ages could be induced to feed on maimed fruit flies placed on the water. King, Bradley, and McNeel (1942) reported that larvae of *P. howardii* would devour small pollywogs. Brine shrimp which are used widely as food for tropical fishes were found to be sufficient as sole diet for the predaceous instars. They took the shrimps without difficulty although development was slower and mature larvae were smaller than was the case with those fed larvae of mosquitoes.

Cannibalism among the predaceous instars of *P. howardii* is common and may be induced by over-crowding and by a lack of food. One reason is that they feed indiscriminately, and, since larvae may strike at any approaching animal small enough, they often catch one of their own kind. In instances of cannibalism observed, the stimulus to strike is one of contact more often than one of motion.

Larvae of *P. howardii* in the second, third, and fourth instars are voracious feeders. In order to demonstrate the number of larvae of mosquitoes that a predaceous larvae may consume during its larval stage, larvae were reared individually and counts were made of the number of larvae of other mosquitoes eaten. For this purpose larvae of *Aedes vexans* and *Culex pipiens* were used as prey. Second instar larvae of *P. howardii* were fed on first instar larvae of *A. vexans*, third on second, and fourth on fourth, respectively. Larvae in the last instar were large enough to feed easily on those of the corresponding instar of *A. vexans* without any difficulty. Data in table 5 indicate the number of larvae which may be consumed by a predaceous larva reared in the laboratory to the pupal stage at a temperature of 25° C.

Table 3.—Effect of temperature on the hatching interval of eggs seven days old of *P. howardii* with nutrient broth in the laboratory

Temperature	Eggs Used	Percent larvae hatched			Total	
°C	Number	0–5 hr.	6–10 hr.	11–24 hr.	Number	Percent
20	46	0	0	0	0	0
22	56	0	58	40	55	98
25	95	0	100	0	95	100
30	46	91	5	0	44	96
35	62	95	0	0	59	95
40	44	0	0	0	0	0

Larval development. Larvae grow more rapidly than the prey species of mosquito even though the fully developed insect is more than twice as large as prey larvae. The first instar is completed within 18 hours at 25° C. whereas associated species require 24 or more hours in the same media. The predaceous instars are completed in one day except the fourth which may take 1 day for feeding and a day or longer as a prepupa.

Pupal development.—The rate of development of pupae in the laboratory is from two to three days with the average time of 2.4 days at a

Table 4.—Effect of immediate pre-hatching exposure to 4° and 25° C. on the hatching of eggs of *P. howardii* in nutrient broth in the laboratory

Exposure in Days 4°/25°	Eggs used	Larvae Hatched	
	Number	Number	Percent
7/0	53	51	96
7/4	58	57	98
7/30	54	54	100
21/7	25	24	96
100/7	21	20	95
0/7	50	46	92
0/25	39	39	100
0/100	50	48	96

temperature of 25° C. In the field, where conditions are more variable and generally cooler water prevails, the pupal stage may be prolonged as much as 6 to 7 days. In all cases, the male emerges as much as 10 to 15 hours earlier than the first female.

Adult feeding.—The adult of both sexes feed on sugar solutions absorbed by cotton wool and fruits, such as banana, prunes, and raisins in the laboratory. The females feed as well on blood whenever offered. In the field adults feed on nectar (Haeger, 1955). The females will feed on blood of humans or pigeons in the laboratory any time beyond 3 days of emergence. Not more than one complete blood meal was taken per day by a female if fed to repletion. One may feed a second time during the same day if the first meal was interrupted. The number of blood meals taken by caged animals may vary from 1 to 6. One blood meal may be sufficient for the initial oviposition, but most females observed took at least two blood meals before oviposition. Subsequent blood meals were taken at intervals of 2 to 3 days. After the first batch of eggs is laid, a female may also take from 2 to 3 blood meals with intervals of no feeding of 2 to 5 days duration. Mitchell (1907) reported that females fed 2 to 4 times before the first oviposition and thereafter at intervals of from 2 to 4 days. She also found that the adult will usually feed once before mating, sometimes within a few hours after emergence, and will also feed immediately after depositing eggs. Hungry unengorged females will instantly fly on to a hand or arm when inserted into the cage. Blood meals were taken in both complete daylight and in total darkness.

Adult mating.—The observations of mating of *P. howardii* under caged conditions are similar to those previously made by Horsfall (1955). Mating will occur very readily in cages in which the adults were confined. Unlike other species of floodwater mosquitoes, the adults were never observed to swarm, and mating was not confined to any particular time of the day. Mating in flight was never completed although the males may intercept the females in flight. Males were continuously active seeking out the females the first few days following emergence. In mating the male normally approached the female from the side and, being smaller in size, slipped under the female to face her in a venter-to-venter position. Copulation was not immediate after both insects were in position but a brief pause of 3 to 5 seconds was held, after which the male suddenly made contact. Copulation did not last more than 4 or 5 seconds. The male may attempt copulation more than once if contact is broken before that interval. The adults of both sexes may mate more than once. An interesting account of the mating behavior of this species in the field has been given by Provost (1958).

Table 5.—Rate of consumption of larvae of *Aedes vexans* by larvae of *P. howardii* in the laboratory

P. howardii larval instar	Number of larvae fed	Number of larvae of *Aedes vexans* consumed														
		1st instar			2nd instar			3rd instar			4th instar			Total		
		Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
1st	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2nd	7	33	25	28±1	—	—	—	—	—	—	—	—	—	—	—	—
3rd	7	—	—	—	41	35	38±1	—	—	—	—	—	—	—	—	—
4th	7	—	—	—	—	—	—	—	—	—	78	69	74±1	—	—	—
Total	7	—	—	—	—	—	—	—	—	—	—	—	—	150	132	139±2

Adult oviposition.—The sites of oviposition in the laboratory consisted of moist cellucotton or cheesecloth placed in petri dishes. The layer of cotton was $\frac{1}{4}$- to $\frac{1}{2}$-inch in thickness and was kept moist at all times. The females deposited their eggs among the folds or cracks and generally along the edges of cotton bordering the walls of the petri dish. Seldom were eggs laid entirely exposed and in most cases the eggs were imbedded in the damp cotton. The eggs were deposited on moist horizontal surfaces. No eggs were deposited on surfaces which were dry or vertical.

Observations on the rate of oviposition were

made on females kept in groups and individually. From one group of 12 females, a total of 841 eggs were collected within a period of 17 days. From a second group of 8 females, 224 eggs were collected through a period of 29 days. In the latter group, oviposition was staggered throughout the interval of 29 days, in which there was no egg laying for a period of 18 days. Females in this group however fed readily on blood throughout this period.

From records of nine females taken individually, the number of batches of eggs deposited by a female may vary from one to four, with a female occasionally staggering or prolonging one batch of eggs along an interval of 1 to 3 days. The number of eggs per batch may vary from a minimum of 31 to a maximum of 104 with an average number of 58 eggs per batch. Mitchell (1907) found that generally a female will lay 2 or 3 batches of eggs, or as many as 9 batches of eggs with 12 to 65 eggs per batch. The highest total number of eggs collected from one female in the laboratory was 259 eggs.

Adult longevity.—Like most species of floodwater mosquitoes, *P. howardii* has a relatively short life as adults. At room temperature males rarely lived 8 days in the laboratory, while females lived up to about 5 weeks. One group of 12 females had a mean longevity of 28±7 days. Another group lived less than 2½ days. One female lived 37 days. Morgan and Dupree (1903) kept one female alive for 38 days.

The colony of *P. howardii* was maintained for seven generations in the laboratory before it was discontinued.

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OBSERVATIONS ON A UNIQUE MONSTER EMBRYO OF WYEOMYIA SMITHII (COQUILLETT) (DIPTERA: CULICIDAE)[1]

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ABSTRACT

This monster was found in 15 out of 1,570 fertile eggs inspected during the colonization of the pitcher plant mosquito. Each consisted only of two apparently complete abdomens fused in the region of the first abdominal segment of each. The "anterior" abdomen was doubled back and occupied the anterior one-third of the egg; the "posterior" abdomen was straight and occupied the posterior two-thirds of the egg. A living embryo exhibiting duplication in the longitudinal axis with complete absence of head and thorax is believed to represent a hitherto unreported type of teratological phenomenon.

Studies of spontaneously occurring abnormal or monster individuals in the Culicidae have for the most part been restricted to instances of chaetotaxal variation among larvae and gynandromorphism among adults. The work of Gaud (1957) is typical of a number of preceding ones which dealt with duplication of larval hairs, especially the clypeal hairs of *Anopheles* larvae. Other larval anomalies have involved those of irregularities of antennal and siphonal structure as well as of a single instance of a unispiraculate condition. Cases of gynandromorphism among mosquitoes have recently been summed up by Kitzmiller (1953). It is the purpose of this work, however, to describe a unique teratological phenomenon encountered with embryos of the pitcher

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plant mosquito, *Wyeomyia smithii* (Coq.). To the knowledge of this writer, the type of monster embryo to be discussed below has been unknown among the Culicidae, and, moreover, has never before been reported among any of the Insecta.

MATERIALS AND METHODS

All embryological and larval materials utilized for this study were derived from apparently normal parent *W. smithii* stock originally obtained from Itasca State Park, Clearwater County, Minnesota, in the summer of 1957. The methods of maintaining the laboratory colony of this species are given elsewhere (Price, In press). The specimens described below all represent members of either the F_1 or F_2 generation of this laboratory colony.

Each monster embryo first was observed in the unhatched state, the rather transparent chorion of the egg allowing those eggs containing monster embryos to be distinguished from those which were infertile or contained normal embryos. In fact, the details of the major setae, such as in figures 3 and 4, can be seen readily when the egg is observed in a hanging drop under a compound microscope. The eggs with monsters in them then were ruptured carefully with dissecting needles and the monster either was gently extricated or at times was allowed to wiggle free itself. Once freed in distilled water, a cursory examination of each was made to confirm the nature of the abnormality and the material was then prepared for permanent study mounts.

Whole mounts of three monster specimens were made; the unusual structure of these monsters made it more convenient to study their external morphology from lateral mounts. For comparative purposes, corresponding lateral mounts of normal first-instar larvae were made. Internal structure was studied from serial sagittal sections of five monsters; these were compared to similarly prepared sections of normal first-instar larvae.

OBSERVATIONS

The monster embryo, after removal from the egg, is seen to consist of two abdomens—one which occupies the anterior one-third of the egg, and the other the posterior two-thirds of the egg—fused together in the region of abdominal segment I of each (fig. 1). The former will hereafter be referred to as the anterior abdomen and the latter as the posterior abdomen. Segmentation is obscured in the region of the junction; however, reference to the chaetotaxy of the normal larva of *W. smithii* (fig. 2) readily reveals the segmental relationships. Each side of abdominal segments I–III bears a pair of long setae and each side of abdominal segments IV–VI bears a single long seta. Abdominal segment VII shows no pronounced long lateral setae. Segments VIII–IX are easily recognizable by various structural elements. Aside from a ventral displacement of the principal laterals of the first abdominal segment of the monster embryo, the external morphology of each abdomen of the monster agrees in virtually every detail with the comparable abdominal portion of the normal *W. smithii* first-instar larva. There is no external indication of either a head or a thorax.

The appearance of the chorion and the dimensions of an egg containing a monster embryo are similar to those of one containing a normal embryo. The only way to distinguish a monster-bearing egg from a normally embryonated egg in the unhatched state is to observe the structure and chaetotaxy of the enclosed embryo. After incubation for 48 to 72 hours at room temperature, the lateral aspect of the normal fully-embryonated egg invariably appears as shown in figure 3. The most obvious feature is the head, with its conspicuous pair of eyes and dorsal egg burster, located in the blunter anterior third of the egg. The setal arrangement shows four of the major groups of thoracic hairs extending forward along the ventral surface of the embryo, the remaining more dorsal ones extending posteriorly. The long double lateral hairs of abdominal segments I–III as well as the ensuing long single laterals of abdominal segments IV–VI also are appressed to the ventral region of the embryo. The two extremely long hairs of the dorsal brush of the anal segment may be seen extending anteriorly to the cephalic region.

Contrasted to the normal embryo, the monster embryo enclosed in the egg reveals no structural features associated with the head or thorax (fig. 4). Instead, all that are in evidence are the major abdominal laterals lying across what typically would be the dorsal portion of the normal embryo and the hairs of the two terminal anal segments, one group emanating from the posterior portion of the egg and the other from the mid-ventral region. Careful extrication of the monster embryo reveals that the entire specimen occupies an inverted position when compared to the normal position. The ventral region of the abdomen lies along the convex surface of the egg, instead of along the flattened, slightly concave surface as that of the normal embryo does. The posterior abdomen, possibly representing that of an inverted normal abdomen, is arranged in an extended position in the posterior two-thirds of the egg; the anterior abdomen, replacing the head and thorax of the normal embryo, extends forward from the point of union until a doubling back is found at the level of segment VI. The arrangement is thus such that the last three abdominal segments of the anterior abdomen are flexed toward the middle of the egg and come to lie against the preceding segments. Generally the anterior abdomen is slightly more slender than its posterior image, but that is the only difference noted between the two halves.

The internal structure of the embryo monster

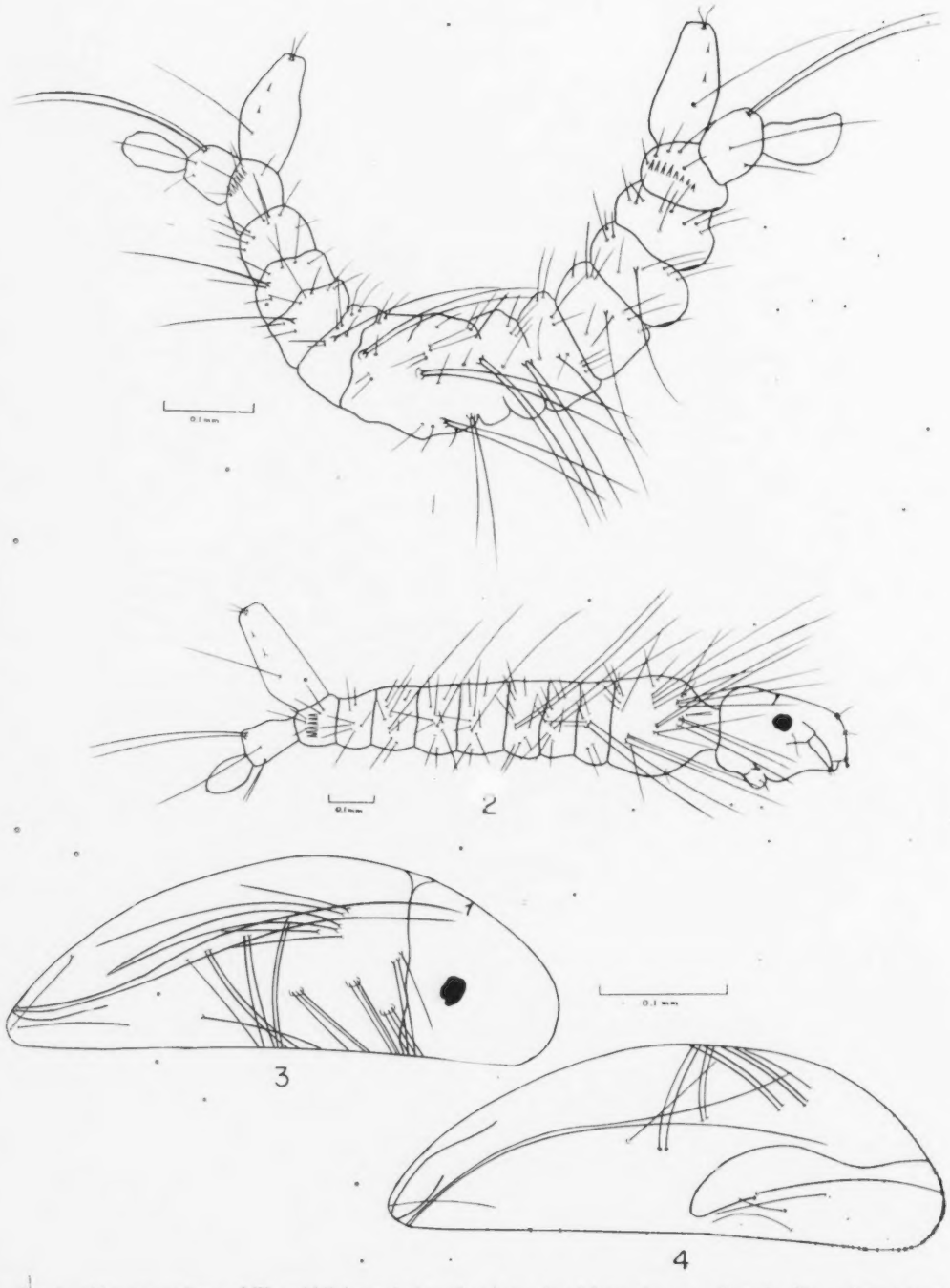

FIG. 1.—Monster embryo of *W. smithii*, lateral view after being freed from the egg. FIG. 2.—Normal first-instar larva of *W. smithii*, lateral view. FIG. 3.—Normal embryo of *W. smithii* as it appears within the egg, lateral view. FIG. 4.—Monster embryo of *W. smithii* as it appears within the egg, lateral view.

verified what was indicated externally. The midgut, demonstrating excellent cellular detail, is wide and continuous from the level of abdominal segment V of one abdomen to segment V of the other abdomen. At those points, it narrows and convolutes, giving evidence of hind-gut structure. Unfortunately it was not possible to follow the details of the hind gut, but it is believed that the digestive tract of this monster very likely runs from anus to anus. Indications of malpighian tubules are also present in the terminal portions of both abdomens. The ventral ganglia of abdominal segment I of one abdomen are apparently fused with those of segment I of the other abdomen to form a proportionately larger ganglionic mass; this is followed in each direction by a discernible series of six to seven normal-appearing pairs of ventral abdominal ganglia. Comparison of this morphological pattern with that of a normal first-instar larva shows close agreement between the two. Thus, both the external and internal morphology, when compared to that of a normal individual, lead to the opinion that this embryo monster is composed of two fused, apparently morphologically complete, abdomens with no indication of any portion of a head or thorax.

Most normally-embryonated eggs hatch after an incubation period of 3 days. One should bear in mind at this point that the eggs of *W. smithii* are generally laid singly and usually directly upon the water surface. The eggs float in such a manner that the ventral side of the embryo is uppermost; in other words, the eggs float in a position inverse to that shown in figures 3 and 4. The egg burster splits the dorsal surface of the egg approximately one-fourth of the way from the anterior end and the cap opens along a spiral line. The larva frees itself into the water from the dorsal side. The necessity of an egg burster for hatching of *W. smithii* makes it evident that the discovery of a monster such as that just described is dependent upon dissection of unhatched eggs. It has been a routine procedure in the establishment of the laboratory colony of this species to inspect all unhatched eggs to determine the possible reason for their not hatching. As a result of this, the first four monster embryos were found in a batch of 34 eggs laid on February 23, 1958. It was at first thought that this was probably an isolated and extremely rare occurrence; however, an additional 11 similar monsters occurred over the next 2 months, making a total to date of 15 monster embryos from eggs laid on at least 8 different days. When one considers that these 15 similar anomalies occurred in a total of 1,570 fertile eggs laid over that period, there is a rate of occurrence of 0.96 percent. These abnormal embryos were most certainly derived from at least three different females, and probably more were involved. Of the remaining fertile eggs, 1,490 hatched normally; 25 remained unhatched, yet were alive and apparently normal; 19 more unhatched eggs were fertile and normal, yet dead; and 21 comprised a group of unhatched embryos, both dead and alive, showing various abnormalities, yet bearing no obvious relationship to the two-tailed monster described above. These individuals were either improperly oriented in the egg or else had a misplaced eye, egg burster, or some other cephalic anomaly. Only 227 eggs were infertile, a lower percentage of infertile eggs than that reported elsewhere (Price, In press).

All 15 of the two-tailed monster embryos were alive when extricated from the egg. They typically demonstrated a thrashing movement of each abdomen; when prodded with a needle, they would snap the tips of their two abdomens together. In one instance, a monster was carefully freed from the egg and allowed to remain in isotonic saline. It remained alive and capable of movement for 24 hours, at which time it was so feeble that it was killed and fixed for further study. With no means for feeding, coupled with the dangers inherent with forced hatching of embryos, it is doubtful if these embryos would ever survive much beyond this.

DISCUSSION

The discovery of the monster embryos of *W. smithii* poses a number of interesting, and as yet unanswered, questions. The existence of a living mosquito embryo composed of a fusion of a virtually complete posterior and a similar anterior abdomen, with no evidence of cephalic or thoracic structure, presents an abnormality that, to the knowledge of this writer, has not been encountered previously in any insect. When one consults the literature reported to date on the teratology of insects, it becomes evident that there are papers dealing with numerous different phenomena distributed among many orders of insects. It is beyond the scope of this study to go into a review of this material, but these reports deal primarily with an anomalous appendage or other external or internal body structure or even with twinning of anterior portions or entire individuals. In all naturally occurring monsters, the head and thorax are still represented at least to some degree. Cappe de Baillon (1927) has presented a classification of monsters and nothing in his summary of this subject is comparable to the two-tailed mosquito embryo. He has noted symmetrical embryos with opposed cephalic extremities, an instance which is opposite to that noted in the present study. Cappe de Baillon makes the statement that the double monster with a doubled abdomen is very rare, the only one encountered by him being an orthopteran completely doubled and joined along the dorsal surface. It is doubtful if he had in mind a situation of a monster consisting only of two abdomens.

Specimens that demonstrate a doubling of major body regions invariably possess indications

of head and thorax and the doubling is generally on a transverse plane. Richards and Miller (1937), in reviewing the work of Seidel on *Platycnemis*, state that duplication never occurs in the longitudinal axis, seldom in the dorso-ventral axis, but commonly in the transverse axis. This statement, of course, refers primarily to knowledge derived from a study of indeterminate eggs, such as those of *Platycnemis* and *Tachycines*.

Based upon the study of a few species of higher Diptera, the generalization has been made that the eggs of Diptera represent a determinate or mosaic type. If this also applies to the lower Diptera, including the mosquitoes, then the embryonic parts of this monster are mapped out before the egg is fertilized. In other words, the malformation is a result of some maternal influence, and whether this is of genetic nature or a result of some other phenomenon can not yet be said. If this is genetically controlled, the continued inbreeding in the laboratory might result in a higher percentage of monsters.

The regions of the head and thorax are believed to be so important in the development of the insect embryo that the question arises as to how this monster embryo can develop as it does and become an intact living entity with apparent absence of these vital regions. A differentiation gradient seems to emanate at the level of the first abdominal segment and pass anteriorly and posteriorly from this point.

The repeated formation of such a monster at the relatively high rate of approximately 1 percent makes one wonder whether he is dealing here with a chance phenomenon limited only to *W. smithii*, and possibly only to those of the Itasca State Park region, or whether this might involve a more widespread occurrence among other mosquito species as well as, possibly, other insects. It will await the colonization of *W. smithii* obtained from other regions, as well as inspection of unhatched eggs of other species, to contribute information on this.

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BOOK NOTICES

THE GRASSHOPPERS AND LOCUSTS (ACRIDOIDEA) OF AUSTRALIA. VOLUME III, FAMILY ACRIDIDAE: SUBFAMILY CYRTACANTHACRIDINAE, TRIBES OXYINI, SPATHOSTERNINI, AND PRAXIBULINI. By JAMES A. G. REHN. 273 pp., 29 pls. (402 figs.). Commonwealth Scientific and Industrial Research Organization, Australia. Melbourne, October 1957.

To orthopterists familiar with Volume I (Tetrigidae and Eumastacidae, 1952) and Volume II (Acrididae: Subfamily Pyrgomorphinae, 1953) of this series, no review is necessary. For them each new volume of this standard reference work is an additional tool to lighten the task whenever information on Australian grasshoppers is desired. Furthermore, basic information on higher categories of Acridoidea, particularly concerning Old World members, is included, so that this series naturally becomes an indispensable source book.

For entomologists interested in trends and general aspects of taxonomic publications it may be noted that this volume treats 41 species and subspecies (21 new) in 13 genera and subgenera (1 new). The three volumes together cover 165 species and subspecies (85 new) in 42 genera and subgenera (11 new). At least one more volume will be required to complete the Cyrtacanthacridinae, "spine-throats", probably two more for remaining groups, and a final volume to bring together much material on distribution and other general aspects, so that about seven volumes are planned. The need for the publication space indicated, even though species of grasshoppers do not occur in the numbers that characterize certain major orders, is accounted for by the very full descriptions, complete distributional data on specimens examined, and detailed illustrations. The photographs of whole specimens in Mr. Rehn's papers probably are the finest being published on Orthoptera. In Volume III there are original illustrations of all but one of the species and subspecies, that one being known only from type material preserved in Stockholm.

Cited records show that specimens of all but about ⅛ of the 41 species and subspecies here treated are now deposited in American museums; this fact suggests the adequacy of collections already available in this country to future orthopterists as a byproduct of Mr. Rehn's work. The majority of type specimens rightfully are returned to Australia to serve as a basis for future work there, something never available following earlier work by Sjöstedt and other orthopterists studying outside of Australia.

About a third of the 369 footnotes explain locations or some other aspect of geography, and the care given to locating each collecting place is admirable, though some writers might prefer to present equally complete information without utilizing so many footnotes. As

one who frequently has been a guest in Mr. Rehn's laboratory and has seen his methodical pattern of study and the constant effort to give a geographic sense to his conclusions, I appreciate the thorough documentation of these volumes and the basic feeling for zoögeographic principles which colors the discussions.

Among the most interesting Australian grasshoppers are those of the genus *Kosciuscola*, comprising five flightless alpine species which are especially notable for their ability, as demonstrated in three species, to change color in response to temperature changes. Color changes are best shown by *K. tristis*, in which at temperatures below about 59° F. the head, pronotum, and certain other body parts are black, but above about 77° F. these parts are largely blue or greenish blue. Mr. Rehn quotes extensively from the important papers published on *Kosciuscola* in 1954 (Australian Jour. Zool. 2: 309–363) by Drs. K. H. L. Key and M. F. Day, who showed that in nature these grasshoppers change their color after being warmed by the sun on mountain tops. The color change is believed to be brought about by a migration of two types of granules within the epidermal cells.

Two of the three tribes treated in Volume III are new, the Spathosternini including the Afro-Oriental genus *Spathosternum* in addition to the Australian *Laxabilla*: the Praxibulini include four endemic Australian genera. Mr. Rhen has deferred detailed discussion of tribal and generic relationships within the "spine-throats" until completion of the subfamily. He has utilized the aedeagus and epiphallus of males to some extent in defining tribes and genera, but has not reported much use of those organs in separating species, and it is probable that they will be increasingly helpful to future students.

For the incentive and support leading to the publication of this series hearty commendations are due to the Commonwealth Scientific and Industrial Research Organization, and in particular to Dr. Key who has been closely associated in the cooperation which is reaching a productive stage so successfully.

ASHLEY B. GURNEY.

THE FAUNAL CONNECTIONS BETWEEN EUROPE AND NORTH AMERICA, by CARL H. LINDROTH. With a foreword by P. J. Darlington. John Wiley and Sons, N. Y. 344 pp., 61 figs. $15.00 (Cloth bound, 23.6 cm.)

The question of which elements of the fauna are common to North America and Europe, and the probable explanation for different distributional patterns which fall in this category, have long interested zoologists. In this book the author, who has been described by a leading American coleopterist as currently the foremost coleopterist of the World, has produced a very scholarly analysis, which deserves a preferred place on the shelves of entomologists. It is based on a careful study of accumulated facts and a great deal of first-hand research in both the laboratory and field, on both sides of the Atlantic. In the past, many conclusions were based on inaccurate species-lists or fanciful explanations. Lindroth, who has been located mainly in Stockholm and Lund, approached this problem logically, following a long-time specialty in the Carabidae of northern Europe and excursions in Iceland. Two summers were spent studying the fauna of Newfoundland, and finally, in order to investigate sources of introductions brought about by man, the ballast-loading places of the ships leaving England for America in colonial times were examined.

Chapter I consists of lists, with supporting annotations, of animals which occur on both continents, for selected groups ranging from mammals to earthworms. The groups are selected from those "sufficiently known with regard to taxonomy and distribution", though even then the state of our knowledge varies widely from group to group. Among arthropods, Coleoptera, Lepidoptera, Diptera, Hymenoptera, Odonata, Orthoptera, spiders, centipedes, millipedes, and terrestrial isopods are treated, though in most cases only for certain families. An attempt has been made to get the most authentic information available, and the lists show critical appraisal. Certain of the lists, however, are doubtless subject to minor corrections at the hands of specialists. For instance, I believe that a grasshopper, *Chorthippus longicornis* (Latr.), should be included in the list of saltatorial Orthoptera, and colleagues in two other groups have suggested changes. Orders with simple metamorphosis would have been better represented if one or more families of Hemiptera or Homoptera could have been included.

Chapter 2 concerns the "human transport of animals across the North Atlantic," and it begins with a discussion of the main criteria for recognizing an introduced species as a non-indigenous element. Detailed examples of introductions to particular sections of North America, such as Newfoundland, New England, Nova Scotia, and the Pacific Northwest, are presented. The discussions of ballast-places in southwestern England is especially informative, based as it is on thorough field work and keen insight into conditions which presumably existed in colonial days.

Zoogeographers will be most interested in Chapter 3, "The true, pre-human relationship between the Palaearctic and Nearctic faunas". First comes a consideration of Amphiatlantic species, those "common to Europe and North America but absent from Asia and thus believed to form instances of direct faunal exchange across the North Atlantic." Further on, present chances of spontaneous transatlantic dispersal, theories of earlier land-connections, circumpolar animals, and the fossil evidence are treated. Lindroth does not indorse a *complete transatlantic* land-bridge, but he does believe that a land-connection reached from northern Europe to Iceland and Greenland. The reasoning behind this conclusion appears very sound, as for example in the detailed analysis and graphic presentation (pp. 275–279) of the facts relating to *Bembidion grapei*, a European beetle of variable wing-length which also occurs in Iceland and Greenland. Wegener's hypothesis of continental drift is not supported by Lindroth's facts. If drift occurred, Lindroth believes it was in so early a period that its biological consequences cannot be traced. As to the methods used by Jeannel to support Wegener's hypothesis, Lindroth characterizes them as "not of science, but of faith." He likewise rejects an Atlantic land-bridge in the area of the West Indies.

Each of the three chapters has a bibliography, and there is an Index to Chapters 2 and 3. Illustrations, especially the maps, are numerous and well executed. Conclusions (p. 322) are stated briefly and clearly. For the groups treated, 908 animal species are common to the two continents, of which between 375 and 417 are thought to have been introduced with man. Those man has assisted from Europe to North America are about 10 times as numerous as those carried in the opposite direction. It is conjectured that the total number of Eur-American non-marine animals amounts to more than 5,000. A comparative study of the Alaskan and Northeast Siberian faunas is said to be the most important task for the future.

ASHLEY B. GURNEY.

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A Cyanamid Report

MALATHION FOR DIRECT APPLICATION ON ANIMALS

With newly-granted residue tolerances, malathion can be applied directly to beef cattle, poultry, and swine. This is the result of three years of extensive research in 11 states. The work proved conclusively the safety and usefulness of malathion as a spray for controlling cattle and poultry lice, poultry mites (northern fowl and chicken red mite), and cattle and poultry ticks. In addition, malathion dust may be applied to nests, litter, and floor space. Roost paints using malathion emulsifiable liquid may also be used in poultry houses. In addition to spraying beef cattle with malathion for lice control, rubbing devices incorporating the product have been most effective in suppressing lice and horn flies.

Do not apply malathion to lactating dairy cows, since it has not yet been accepted for this use, nor should it be used on calves under one month of age.

PROTECTANT FOR STORED GRAIN

With newly-granted residue tolerances for malathion on wheat, barley, oats, rice, rye, corn, grain sorghum, and peanuts (post-harvest), grain handlers storing grain have a method of protecting grain from loss to insects. Malathion, either in dust or spray form, *applied to the grain as it is being loaded into bins*, affords protection against confused flour beetle, rice weevil, granary weevil, saw-toothed grain beetle, flat grain beetle, red flour beetle, rusty grain beetle, lesser grain beetle, and Indian meal moth. It is also suggested as a residual wall, floor, and machinery spray in grain elevators, in treating truck beds, box cars, and ships' holds before loading grain. Where Indian meal moth infestations develop, *surface* applications of malathion dusts or sprays at prescribed intervals afford protection.

NEW USES FOR MALATHION ON CROPS

Tolerances have been established on 37 additional crops, including:

Vegetables	Fruits
Asparagus	Bramble family
Carrots and other root crop	Nectarines
Garlic--Leeks--Shallots	Quinces
Several leaf vegetables	Currants
Pumpkins	Gooseberries

Also, small grains, cotton, mushrooms, peppermint, spearmint, corn and rice. With these additions, malathion is now recommended on 93 crops.

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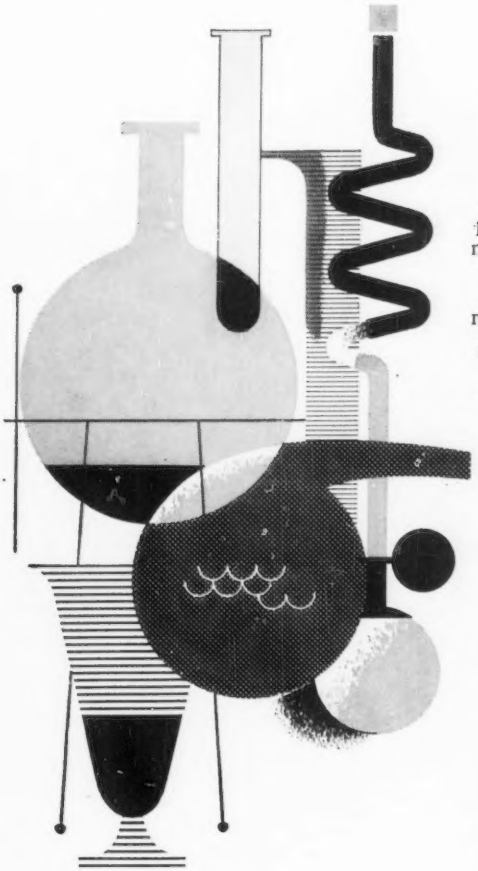

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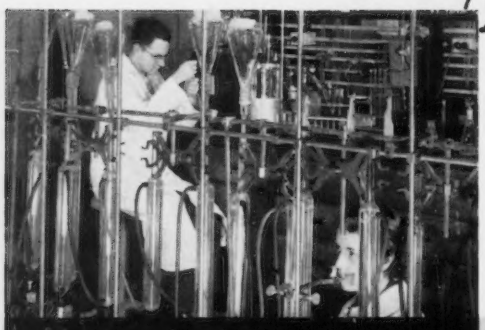

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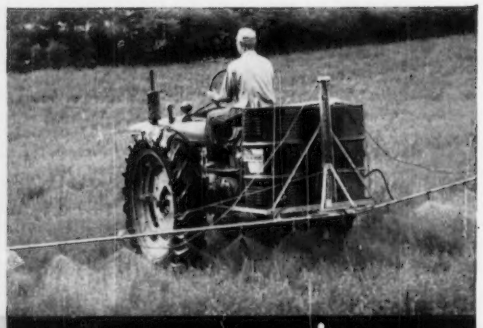

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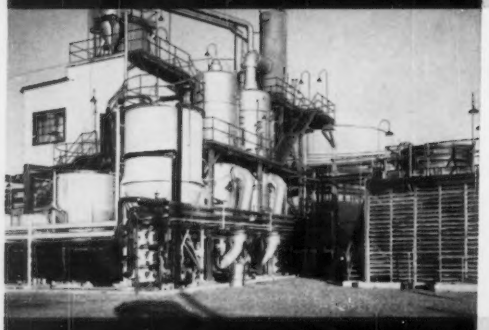

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